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UNITED STATES CRUISER NO. 12—THE COLUMBIA.

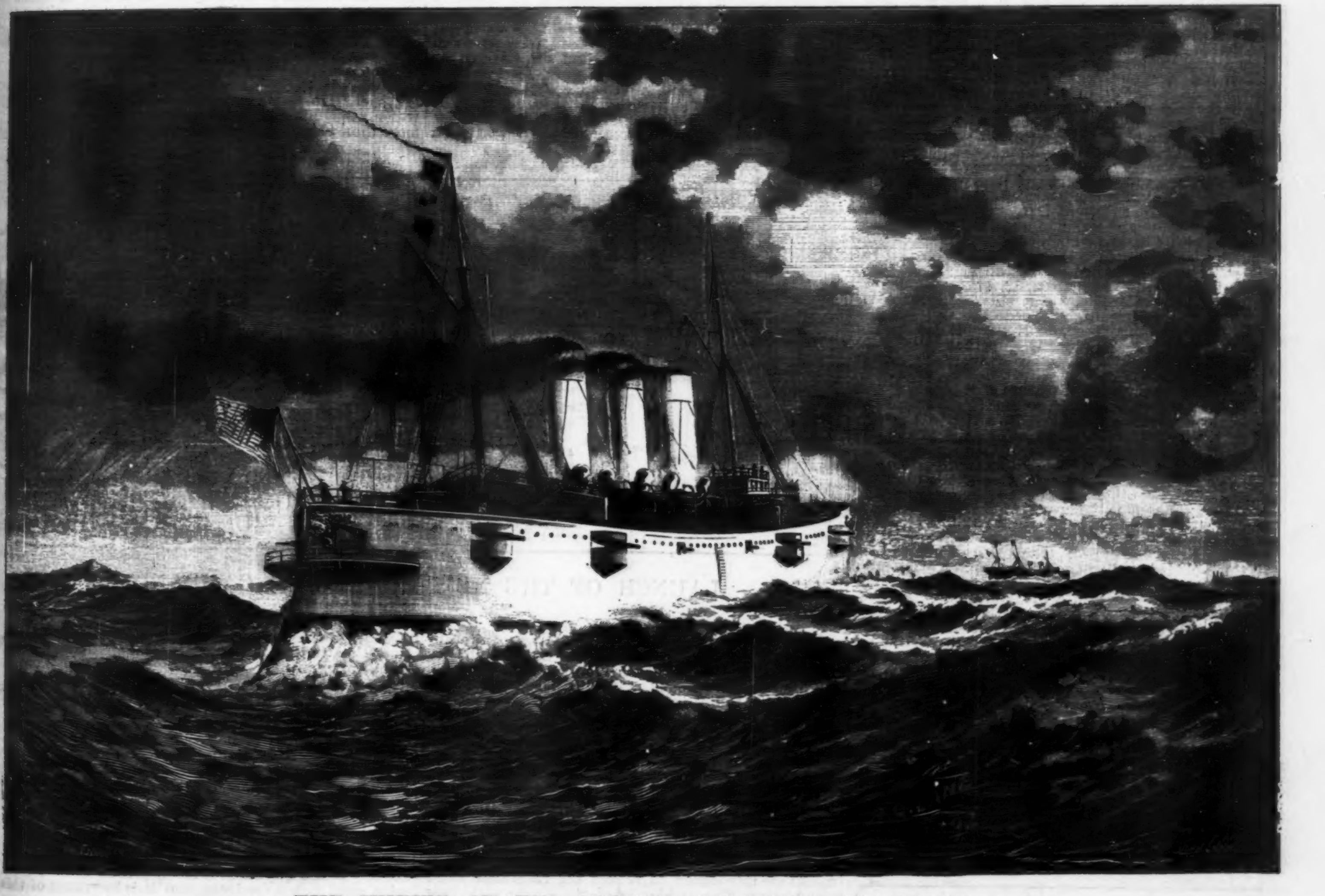
On July 26, 1892, there was launched at Philadelphia, Pa., from Cramp & Sons' shipbuilding yards on the Delaware River the hull of the biggest vessel of the new navy of the United States. She is officially known as protected steel cruiser No. 12, but is popularly called the Pirate, although at the launching she was christened Columbia. She is designed especially as a commerce destroyer, to carry on a similar feature of naval warfare to that practiced by the celebrated Confederate cruiser Alabama, under the command of Admiral Semmes, Confederate States navy, nearly thirty years ago. The Alabama captured and destroyed an enormous number of merchant ships, so that this one vessel did an amount of damage that has made her celebrated in naval records; but since her day has grown up the steamship commerce, from the slow tramp steamers to the record-breaking ocean racers, and to strike at commerce carried in such vessels with effect will require ships of greater speed and carrying a fairly strong armament. The Columbia, therefore, is not intended for heavy fighting, but for chasing, and with her sister ship, cruiser No. 13, now on the stocks, will be a powerful addition to the navy. Both of them are rated as of the first class, *i. e.*, over 5,000 tons. The engines of these vessels will be of special importance, on account of their power and arrangement, consisting of three triple expansion engines driving three screws.

The Columbia is the first triple screw war ship built for the United States navy, and in her it is expected that the fastest cruising war vessel in the world has been produced, a vessel able to overhaul the fastest transatlantic liner afloat, and destroy or sink any merchant ship now plying the ocean. To make the Columbia the superior of such ocean greyhounds as the City of Paris and the City of New York, of the Inman Line, and the Majestic and the Teutonic of the White Star Line, the fastest ships afloat, the engines of the new cruiser have been built with a view of giving her a maintained sea speed of twenty-one knots and a maximum speed of twenty-two knots. By a maintained sea speed is meant a continuous speed, day in and day out, so long as the bunkers contain coal. The fastest time developed by any of the Atlantic greyhounds has been an average speed closely approaching twenty knots. The Columbia, if she comes up to expectations, must be able to make at all times an average speed of twenty-one knots, almost twenty-five miles an hour. The authorization to build a vessel of the power of the Columbia was given by Congress in an act dated June 30, 1890. This act set aside the sum of $2,725,000 as a maximum expenditure on the hull and machinery. In October of the same year the contract to construct the new vessel was awarded to William Cramp & Sons, ship and engine builders, Philadelphia. This contract was obtained by the Cramps in conjunction with the contract to build two of the new battleships—the Indiana and the Massachusetts. In the case of the Columbia the contract specified a building period of thirty months. The vessel must be fully ready for acceptance by the government in April, 1893. American designs, material and workmanship have been used throughout, in accordance with the policy of the navy department. The first keel plate was laid December 30, 1890, and the first main frame was erected March 21, 1891.

The leading dimensions and particulars are as follows: Length on mean load line, 412 ft.; moulded beam, 58 ft.; normal draught, 23 ft.; displacement, 7,550 tons; maximum speed, 22 knots; indicated horse power, 23,000, or about 3 horse power per ton of displacement; coal capacity on normal draught, 750 tons; maximum coal capacity, 2,000 tons. She will be able to steam at a speed of 10 knots for 26,240 miles or 109 days without recoaling, so that she has an enormous fighting and cruising range. The contractors guarantee an average speed, in the open sea, under conditions prescribed by the navy department, of twenty-one knots, maintained for four consecutive hours, during which period the air pressure in the fire room must be kept within a prescribed limit. For every quarter of a knot developed above the required guaranteed speed the contractors are to receive a premium of $50,000 over and above the contract price; and for each quarter of a knot that the vessel may fail of reaching the guaranteed speed there is to be deducted from the price the sum of $25,000.

A vessel of this class has been contemplated for some years, and in order to make her as perfect and complete as possible before the designs were submitted for approval, a careful and thorough investigation was made of every known design of modern foreign navies, and many improvements made upon these foreign designs. The designs for the hull were made by Theodore D. Wilson, Chief Naval Constructor, and Philip Hichborn, Assistant Naval Constructor. The adoption of triple screws was suggested by Commodore George W. Melville, Chief of the Bureau of Steam Engineering, and the plans for the engines, boilers, and machinery were prepared in this bureau under his supervision. The plans for the armament were drawn up in the Bureau of Ordnance under Commodore Wm. M. Folger, chief of the bureau, and his predecessor, Commodore M. Sicard. The equipments and fittings for the accommodation of officers and crew were provided for by the Bureau of Equipment. Mr. Tracy, Secretary of the Navy, who has done so much for the advancement of the new navy, has taken special interest in this vessel. She was designed with two principal objects in view: (1) Speed; (2) coal capacity. She has, therefore, been given a large tonnage displacement, great length, moderate beam, and great steam power. She has no turrets or projecting gun sponsons. There will be four smokestacks or funnels, and two masts for signaling purposes, without military tops, and carrying no yards. Her complement will consist of thirty officers and 426 enlisted men.

The general structural design of the new vessel is that of a protected cruiser, the magazines, engine rooms, boilers, and steering gear being protected by an armor deck running fore and aft. This armor deck has a thickness of 4 in. on the slopes and 2½ in. on the flat. The top of the beams of the protective deck at the ship's side is 4 ft. 6 in. below the load line, and the center of the beams generally 1 ft. above the load line. The flat portion of the protective deck is worked in two thicknesses of 1¼ in. plates. On the slopes of the protective deck, on that portion lying over the machinery, an additional thickness of 1½ in. is worked on top of the 1¼ in. plates, making the plates 4 in. in thickness. The stringers of the upper deck are 72 in.



THE UNITED STATES CRUISER COLUMBIA—IN CHASE.

wide, of 25 lb. per sq. ft. weight, and tapered at the ends to 54 in. in width, and a weight of 20 lb. per sq. ft. These stringers are filled in between with a 10 lb. plating, extending from end to end. The gun deck stringers are 78 in. wide, tapering to 52 in. at the sides, and having plating of a weight of 15 lb. per sq. ft.

The stern and stem posts are of solid cast steel. The outer flat keel has a weight of 25 lb. and the inner one 22¼ lb. to the sq. ft. The vertical keel has a weight of 20 lb. to the sq. ft. The transverse frames within the double bottom have the main bars 5 in. by 3½ in., and of a weight of 12 lb. per sq. ft. The reverse bars measure 5 in. by 3 in., with a weight of 10 lb. to the sq. ft. The reverse bars have bracket plates of 12½ lb. and 10 lb. plates. Between the double bottom and the protective deck the frame are Z bars, 6 in. by 3½ in. by 3½ in. and of 15 lb. weight per sq. ft., with 15 lb. brackets at the top and bottom. Elsewhere the frames are also Z bars, 6 in. by 3½ in. by 3½ in. and of 15 lb. weight per sq. ft.

The outer bottom plating is generally of 22½ lb. weight per sq. ft. and the inner bottom 12½ lb. weight per sq. ft. The upper deck beams are 10 in. by 5¾ in., of 31½ lb. per ft. T bulbs. The gun deck beams are 9 in. by 3½ in., of 22 lb. angle bulbs; berth deck beams, 5 in. by 3 in., of 11 lb. per ft. angles, and the protective deck beams 10 in. by 3½ in., of 26½ lb. angle bulbs. The fore and aft athwartship bulkheads are of 7½ lb. to 15 lb. plates. They are well stiffened and watertight. The material is of steel throughout.

The battery of the Columbia will consist of one 8 in. breech-loading rifle mounted in the bow as a bow chaser, two 6 in. breech-loading rifles of the forty caliber type, to be mounted just abaft each bow; twelve 4 in. rapid fire high powered ordnance guns distributed in broadside about decks; sixteen Hotchkiss six pounder rapid fire guns, eight Hotchkiss one pounder rapid fire guns, and four Gatling guns. In addition there will be six torpedo tubes for the discharge of automobile torpedoes. The bow is of the ram type, and intended for service for ramming. Over the protective deck, and in the space between this deck and the gun deck, are minutely subdivided coal bunkers and store rooms. This coal space will serve, when filled, as a further protection to the ship's vitals. In addition, a coffer dam space 5 ft. in width is worked next to the side of the ship for the whole length of the vessel. This coffer dam is also divided into bunkers, the bunkers to be filled with a patent fuel, forming a wall 5 ft. thick against machine and rapid fire gun fire. The contents of the coffer dam can, in an emergency, be utilized as fuel. Forward and abaft the coal bunkers the coffer dam will be filled with some water-excluding substance, probably cellulose or woodite. In the wake of the 4 in. and rapid fire and machine guns, the ship's side is armored with 4 in. and 2 in. nickel steel plates. The 6 in. guns are mounted in the open, and protected by 1 in. steel shields attached to the gun carriages. The subdivisions of the vessel are such as to form a double hull below the water line, which will offer great security against disaster from torpedo attacks; and she could, because of her speed, do irreparable damage before she could be caught by any ship that could whip her. The officers and men's quarters are spacious, well ventilated, and will be well lighted.

But the most interesting feature of this vessel, and which we have left to the last, so that it will already be understood what the vessel herself is, lies in the machinery, with its triple set of screws and three independent triple expansion engines. One screw will be behind the rudder on the center line of the ship, and will be a four bladed screw of 10° more pitch than the others. The two other screws will be one on each side of the stern, about 15 ft. forward of the middle screw, and about 4 ft. 6 in. above it, the shafts inclining outward and upward, while the middle shaft will be inclined slightly downward. The two side screws will be three-bladed, and will be set to the pitch found most advantageous on actual trial. By the triple screw arrangement the chances of a breakdown are lessened. If twin screws were used, over 10,000 indicated horse power would have to pass through one shaft to obtain the requisite 20,000 horse power for the speed demanded. With three screws, each shaft is subjected to a strain not exceeding 6,850 horse power per shaft. The shafting will be of forged steel, 16½ in. diameter. For ordinary cruising the central screw alone will be used, giving a speed of about 15 knots; with the two side screws alone a speed of 17 to 19 knots can be maintained, and with all three screws at work at full power a high speed of from 20 to 22 knots can be got out of the vessel. This arrangement will allow the machinery to be worked at its most economical number of revolutions at all rates of the vessel's speed, and each engine can be used independently of the others in propelling the vessel. The screws will be disconnected when not driven by the engines, so as to reduce their resistance.

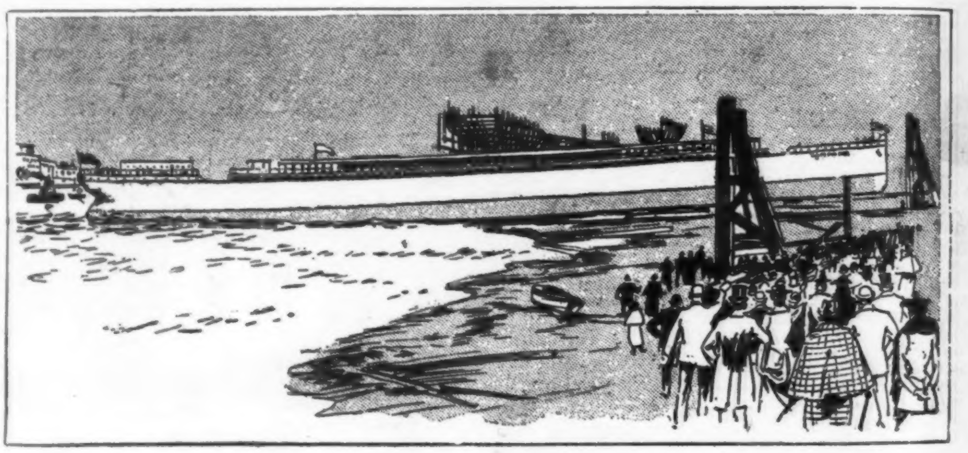
Name.	Navy.	Maximum speed in knots.	Coal capacity. Tons.	Horse Power.	Radius of acti'n or cruising range. Knots.
Columbia....	United States	22	2000	21,000	24,240
Philadelphia..	United States	19·7	900	10,500	12,000
Blake....	British	20	1500	20,000	15,000
Dupuy de Lome...	French	20	700	14,000	4,000
Piemonte....	Italian	21 *	900	12,000	13,000

* Each screw will be driven by a separate and independent triple expansion, vertical, inverted marine engine, and each engine will be in a separate watertight compartment. The cylinders will be 42 in., 59 in., and 92 in. diameter, for high, intermediate, and low pressure respectively, and 42 in. stroke. The air pumps are two vertical single acting lift pumps for each engine, with pump cylinders 22 in. diameter and 20 in. stroke, driven by two simple engines, with cylinders 7 in. by 12 in., arranged to exhaust into the condenser, or into either receiver. Steam will be supplied by eight main boilers, in four separate compartments, and two auxiliary engines on the berth deck, all of the Scotch marine type. They will all be of mild steel, and carry 160 lb. per sq. in. working pressure. The main boilers are double ended, 21 ft. 3 in. long and 11 ft. 8 in. diameter, with eight 42 in. corrugated furnace flues, and 1,128 steel tubes, 2¼ in. diameter. The total heating surface is 43,269 sq. ft.—or 2 sq. ft. per indicated horse power—and total grate area 1,285 sq. ft. There will be five fire rooms placed athwartship. Forced draught will be on the closed fire room, each fire room being supplied with centrifugal fan blowers. There will be evaporators to make up the loss of fresh water to the boilers, and to supply the distillers; also fire and bilge pumps, ice machine, steam ash hoists, capstan engine, electric light engines and plant, ventilating fans, etc. The calculated indicated horse power of the three engines to be developed when the engines are turning over at a rate of 129 revolutions per minute is 21,000. To develop this horse power, forced draught equal to a 1 in. water pressure will, it is presumed, be necessary. The best known horse power developed by the City of Paris before her breakdown was a little under 19,000. The Columbia will exceed the best work of the City of Paris by over 2,000 horse power.

The accompanying illustration represents the general appearance of the Columbia at sea.—*The Engineer, London.*

THE NEW CUNARD STEAMER CAMPANIA.

THE latest successor of the old paddle steamers Great Western and Sirius, the first two steamers to cross the Atlantic, is the Campania, of the Cunard Line, just launched from the Fairfield Yard at Govan. She is the largest ship in existence, and marks a great advance in the annals of steamship building. It was no wonder, therefore, that thousands attended the launch when the vessel was named by Lady Burns, wife of the veteran head of the Cunard Company, Sir John Burns. The Campania's proportions are gigantic. She has a length over all of 620 ft., an extreme breadth of 65 ft. 3 in., a depth from upper deck of 43 ft., and a gross tonnage of about 12,000. She thus comes not much short in her dimensions of those of the Great Eastern, which has perished at the hands of the ship breaker. The Campania, despite her great size, has exceedingly graceful lines. She has a straight stem and an elliptic stern, topgallant forecastle and poop, with close bulwarks fore and aft. Above the upper deck are two tiers of deck houses, carrying respectively the promenade and shade decks. She will be rigged fore and aft, with two pole masts. The writer saw her keel plates laid when in Glasgow about a year ago, and the extent of ground which was taken



LAUNCH OF THE NEW CUNARD S.S. CAMPANIA.

up by this foundation of the vessel was quite sufficient to excite astonishment. But no strength has been sacrificed to speed, as all the scantlings have been specially arranged, and channel and zed bars used to the fullest to increase her strength without adding to her weight. There are sixteen bulkheads, and she will be enabled to float with two or three compartments full of water. She has a flat plate keel, with cellular double bottom from stem to stern, which is fitted to carry water ballast. The shell plating, which is in lengths of 2·6 ft. and over, is on the lap butt principle from the keel plate up to the water line. Above that the plates are butted and fitted with double straps. To enable the twin screws to work freely there is an aperture in the stern frame similar to that in a single screw steamer, and other improvements are introduced to reduce the resistance to free propulsion. The rudder is of the single plate type, and is fitted entirely under water. The vessel has also been built to meet Admiralty requirements for serving as an armed cruiser in time of war. The decks have been specially arranged and strengthened to carry guns, and the steering gear fittings are all under the water line. The vital parts of the ship are also protected.

She will be engined with two sets of the most powerful triple expansion engines ever constructed, and these will be fitted in separate engine rooms, communicating by water-tight doors. Each set of engines is fitted with five inverted cylinders, two high, one intermediate, and two low pressure. These will work on three cranks, set at an angle of 120° with each other, and all having the same stroke. The vessel otherwise will be fitted on the most complete and, in regard to the passenger accommodation, the most luxurious fashion. As an interesting detail it may be mentioned that the weight of the vessel was 9,000 tons at launching, and that her bow was 30 ft. above the level of the river. The lowering of this weight and height was one of the difficulties which had to be met by the engineers, and they so arranged that the vessel, instead of having her stern in line with the north (the opposite) side of the river, was so laid that on launching her course was down the river. So carefully was the work done that within five minutes after entering the water she was at rest, with not a ripple to mark where she had entered the stream.—*London Daily Graphic.*

THE SAND PUMP HOPPER DREDGER THYBORON.

MESSRS. LOBNITZ & Co., of Renfrew, have recently built for the Danish government a sand pump hopper dredger named Thyboron.

This type of dredger is intended to remove sand bars and generally increase the depth of water wherever the bottom is of sand by pumping the latter into a hopper instead of lifting it in the usual manner by means of a chain of buckets. The dredged material may, of course, be removed in ordinary hopper barges, or the dredger may serve also as a hopper, as in this instance. Sand pump dredgers are, as need scarcely be stated, by no means a novelty, for Messrs. Lobnitz have long ago supplied pump dredging machinery for service in the Suez Canal, and, indeed, the main features of the Thyboron are similar to those of the Suez Canal type. She has, however, many improvements to render her specially efficient for her work at Lemvig, in Denmark, and so satisfactory are these, that already she has succeeded in there attaining an output almost double that which was guaranteed by her builders.

The dimensions of the Thyboron are 165 ft. by 34 ft. by 12 ft., and she is constructed with a raised quarter deck and raised fore deck.

An important feature in this sand pump dredger is her light draught of water, she being able to do her work upon an immersion of 6 ft. 3 in. on an even keel. When loaded she carries 700 tons on a draught of about 10 ft. Hence she is able to do the duty for which she was designed, namely, to make a channel through a sand bar upon which there is only 7 ft. of water. In proceeding to dredge by pumping, it is found advantageous upon arriving at the scene of operations to drop an anchor and pay out chain cable, so as to allow the dredger to drift with the wind or current until the cable is taut. If there is neither wind nor current available, one of the twin screw propelling engines is turned slowly astern, and in this way the cable can be made taut, and the dredger kept steady thereby, without having to resort to side or stern moorings. While the cable is being paid out a suction pipe is lowered. Two of these pipes are fitted, and they can be used separately or together. As soon as the vessel is steady the pumping is commenced. Directly the mouthpiece of the suction pipe touches the bottom, the vacuum, which when pumping water only is 6 in., increases to more than 12 in. A mixture of sand and water is then discharged into the hopper, the mixture being sampled from time to time in test tubes 2 in. in diameter and 12 in. long, graduated in percentages. The sample taken immediately after the suction pipe touches the bottom will show from 5 to 10 per cent. of sand. After being at work five minutes the sample will probably show 15 to 20 per cent. of sand in the test tube. During this time the man in charge of the winch to suction pipe will have been gradually lowering the mouthpiece of the latter into the large hole sucked in the sand. As the hole deepens the vacuum rises, and the percentage of sand in the sample tubes increases to 30, 40, and even 50 per cent. That is to say, the pump is then sucking and discharging into the hopper a mixture of half sand and half water.

The proportion of sand to water lifted by the machinery of the Thyboron is much greater than is usual with sand pump dredgers, and it is by reason of this fact, coupled with absolute immunity of the pump from choking, that the efficiency of the Thyboron is largely determined. This result is due both to the power of the pumps and to the arrangements patented by Messrs. Lobnitz for the purpose.

Settling troughs or receivers are set below the discharge pipe for separating the sand from the water as much as possible before discharging into the hopper, and arrangements are made for directing the sand to any particular part of the hopper.

Before leaving for Denmark, tests of the vessel were made. After pumping for twenty minutes on the Mersey bar the hopper was filled to within 2 ft. of the top of the covering, the quantity of sand deposited in the hopper being between 500 and 600 tons.

According to the builders' contract with the Danish government, the hopper was to be filled to overflowing, that is to say, with sand to the level of the coaming. This was done three times in Liverpool, and, with only one pump working, only forty minutes were occupied in filling. The performance was not, however, such as would be advantageous in actual practice, for during the last twenty minutes of each trial the overflow of water running over the side of the vessel contained as much as 30 per cent. of sand. This was, of course, inevitable, as the rush of water must necessarily carry as much sand at the finish as is deposited in the hopper. In regular work it is found useless to fill the hopper in that way, and, of course, it is never done.

The contract requirements demanded that each pump should be able to discharge 1,300 cubic ft. of pure water per minute, but on trial they delivered no less than 2,400 cubic ft. at their normal speed. In point of fact, the Thyboron was able at Liverpool to anchor and load herself with 600 to 700 tons of sand dredging within half an hour, with an expenditure of only 2¼ cwt. of coal. The crew of a sand pump dredger being no more numerous than that of an ordinary hopper dredger, it will thus be seen that sand pump dredging is the cheapest known system of lifting sand.

The Thyboron is fitted with two main boilers, each 11 ft. in diameter, and has twin screw compound surface condensing engines, with 16 in. and 30 in. cylinders, and a 24 in. stroke, the steam pressure being 100 pounds per square inch. She is also fitted with an auxiliary boiler, a steam launch, steam steering gear, steam windlass, and winches. The centrifugal sand pumps are driven by the propelling engines; the machinery is placed aft and the boilers forward, with a watertight passage joining engine room and stokehold. The speed of the Thyboron is 9 knots. It may be remarked that the sand dredger may be used either as at Liverpool, by making a large hole in the sand each time she loads herself—the surface of the sand being leveled by the subsequent scour of the tide—or the sand pump can dredge to a given depth, leaving a level surface, as she trails the suction pipe lowered to that depth.—*The Engineer.*

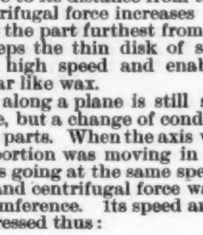
WHAT KEEPS THE BICYCLE UPRIGHT?

To the Editor of the Scientific American:

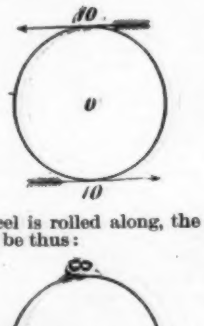
The world of science has long been puzzled over the principles of gyration or centripetal and centrifugal force. What keeps up the spinning top or the rolling wheel and what holds the whirling plate to a center? Attempted explanations are too often a mere change of terms or evasion of the main point, without reaching a true solution of the problem. The answer may be correct, but if I cannot comprehend its full inwardness, it is not satisfactory and awakens distrust. But false premises and conclusions, by being exposed, often lead us onward toward the truth. If we are sure that one of five propositions is true and show that four are false, it is not necessary to demonstrate the truth of the other.

The interesting question now is, What keeps the bicycle upright? The usual answer is, The rider, by his dextrous balancing from side to side and turning the wheel so as to keep the center of gravity over the base. This, I believe, is generally accepted; but it does not satisfy me, because it evades the main, vital point of investigation. To get at this let us first reduce our proposition to its lowest terms by eliminating the rider, which we can do without injury to the main question, which now stands, What keeps a rolling wheel upright? My answer is, to come to the point, Centrifugal force. "Oh, no!" says the scientist; "the wheel moves in a straight line along a plane surface, and centrifugal force can only act on matter revolving around a center." Well, here we agree and we disagree. Let us try and harmonize. It is not half as hard as we think. The trouble is, we do not try, but agree to disagree, and go on antagonizing each other, when it is almost as easy to harmonize our discordant views and work together along common lines of truth and interest. But *revenons a nos moutons,* let us go back to rolling our hoops and see how it is done. The principle of centrifugal force is that it acts on matter moving round a center in proportion to its velocity, and this is relative to its distance from the center. In other words, centrifugal force increases with velocity, and is greatest at the part furthest from the center of motion. This keeps the thin disk of soft iron rigid while turned at high speed and enables it to cut through a steel bar like wax.

A wheel rolling along a plane is still subject to the same laws of force, but a change of conditions changes the relation of its parts. When the axis was stationary while the upper portion was moving in one direction, the lower side was going at the same speed in the opposite direction, and centrifugal force was equal at all points of its circumference. Its speed and centrifugal force may be expressed thus:

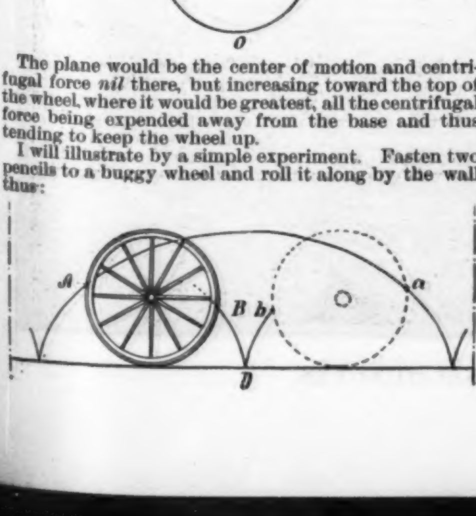


But if the wheel is rolled along, the mathematical expression would be thus:



The plane would be the center of motion and centrifugal force *nil* there, but increasing toward the top of the wheel, where it would be greatest, all the centrifugal force being expended away from the base and thus tending to keep the wheel up.

I will illustrate by a simple experiment. Fasten two pencils to a buggy wheel and roll it along by the wall thus:



A c a will mark the path of the pencil in the upper part of wheel and B D b that in the lower. Their relative length will show the relative velocity, for the first has gone about seven times as far forward and four times as far through space as the other has in the same time. Some cannot see how this can be and yet the wheel remain solid, but to such I only say try it. You must note that the particles of the wheel as shown by the pencils placed thus or at any other point in the wheel are not moving in horizontal lines, but all describe cycloidal curves whose centers are on the base line, thus throwing all the centrifugal force upward from this line and tending to keep the wheel upright as long as it rolls. If not, why not?

J. H. McDIARMON.

Humboldt, Tenn., September 27, 1892.

THE "RENDU" OF ARCHITECTURAL DRAWINGS.

THE study of putting in shadows in drawings has taught us how to determine on the surfaces of bodies exposed to the rays of light the portions which should be brilliantly lighted and those which remain in actual shadow, and also the position and form of shadows cast against the lighted surfaces by projecting objects or planes. The shadows well indicated in a drawing tend very much to enhance the value of the work; but we must not forget that, however well the form of the shadows may be put in, unless the natural effects of coloring, reflected light, and distance are equally well observed, the result will not be what it should be.

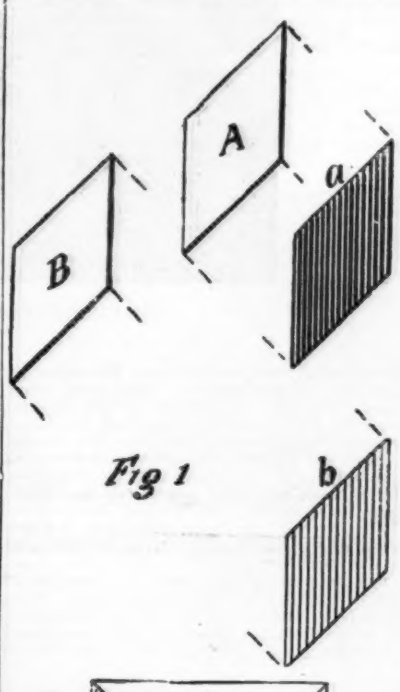


Fig 1

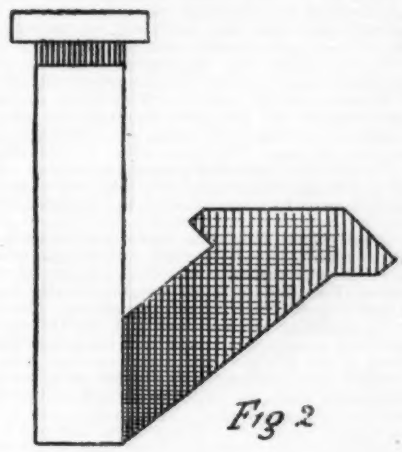


Fig 2

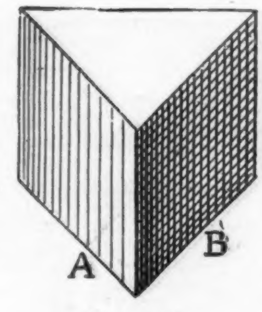


Fig 3

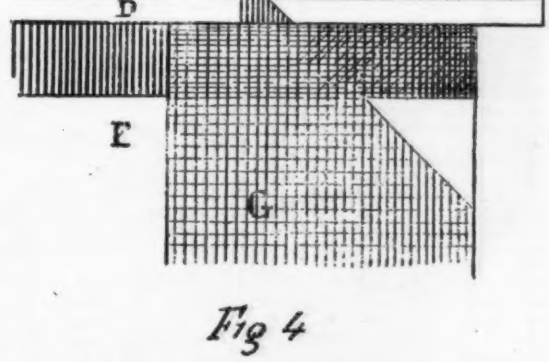


Fig 4

The getting up of architectural drawings, or the "rendu" as it is called in the Continental art schools, is the art of representing conventionally in color or neutral tint the various natural effects of brilliancy, tone, and color in respect to the laws of lighting and distance. We learn the manner in which the rays of direct or reflected light are received by the surfaces of the object, and also the variation of effect with regard to the position of the observer and object, as well as the method of rendering these effects in the drawings by means of color, Indian ink, or neutral tint.

The rays of light, as in the case of shadows, are supposed to arrive from above at an angle of 45° with the horizontal and vertical planes. The visual rays come direct to the eye of the observer, and all these rays are parallel to each other. Now, besides the direct rays of light at 45°, we have the indirect or reflected rays, and these play an important part in the getting up of a drawing.

If we could imagine an object perfectly isolated in space and receiving the rays of the sun, the portions of the object not influenced by the rays of light would be imperfectly black shadow. But if we place near this object another body, also brilliantly lighted, the lighted particles of the second body would send back the rays, and these, striking the parts of the other body in shadow, would tend to light up to a certain degree these shadows, making them appear less black.

The sources of indirect rays are many, but in conventional drawings two only are considered necessary to produce the light and shade effects. These two are the terrestrial rays, or light sent back from the surface of the ground, and the atmospherical rays, light reflected from the atmosphere surrounding the object.

Atmospherical rays are the reflection of the direct rays of light by the innumerable particles contained in the air. Each particle floating in the atmosphere acts as a reflector to the direct rays of light, therefore all the particles mutually sending back from one to another these rays in combination produce the indirect diffused light. We, therefore, understand that the shadows of an object such as a building, resting on the ground and surrounded by other objects, are never absolutely black, but always more or less lighted by the indirect rays from the surface of the ground, combined with the indirect rays from the atmosphere.

There are two kinds of indirect rays—those reflected from polished surfaces and those sent back from unpolished surfaces. A surface in an unpolished state, such as a sheet of unglazed paper, a piece of chalk, etc., appears to be lighted in the same degree of brilliancy all over its surface—no portion will appear to be brighter than the rest. And any change in the position of the object or the observer will not influence to any degree the apparent lighting of the surface. A sheet of iron heated to a red glow is a good example of an unpolished surface. The light sent back from an unpolished surface is, therefore, diffused—that is to say, the rays are equal to each other in intensity, and do not combine with each other.

If we take an example of a polished body, such as a sheet of polished tin, we shall notice that different portions of the surface appear more or less brilliantly lighted, and each movement of the surface or the observer brings about changes in the apparent lighting. The rays sent back from a polished surface are direct or in a combined state.

We may suppose the surface of the earth to be that of an unpolished body; the light reflected from this surface is, therefore, in a diffused state. An object or building reposing on the ground receives to a greater or less degree the indirect diffused rays from its surface. Therefore, the shadows of the building will be affected by the reflected rays from the surface of the ground.

The general shadows in a building should also, for the same reason, become lighter in proportion as they approach the ground or reflecting surface, and come under the influence of the indirect rays. Mouldings in shadow turned toward the ground should, for the same reason, be lighter than those turned toward the sky.

We have said that the particles floating in the atmosphere materially reflect the rays of light, and, sending back indirect rays, tend to lighten the shadows of an object. The more we cover these particles and prevent their reflection arriving to the shadow, the darker will this shadow be. Thus the shadow cast by an object against a lighted surface will become darker in proportion to the distance of the object from the surface—that is to say, the nearer the object the darker the shadow, its nearness preventing the action of a certain proportion of the indirect rays. The shadow of A, Fig. 1, will be darker than that of B. The shadow of a chimney against a roof will be darker as it approaches the base of the chimney, Fig. 2. As the distance between the observer and the object increases, so in proportion does the apparent intensity of color and shadow diminish.

When an object is at a certain distance from us, the rays of light sent back from the object lose their intensity during their voyage through the reflecting particles of the intervening atmosphere. Again, the air between the observer and the object is always more

or less charged with impurities and moisture, the effect being to lessen to a great degree the intensity of the reflected rays. In a pure and dry atmosphere, as in Egypt, the colors appear brilliant even at a great distance.

We will take three planes of distance. For the first plane, that nearest the observer, we may consider the effect of distance as *nil*, and that the colors and shadows retain their utmost degree of intensity. In the second plane, however, the colors begin to combine with the bluish tint of the atmosphere: yellow will appear less yellow and more bluish-yellow; red, less red and more bluish-red; and blue itself less blue if originally dark blue, or more blue if originally light blue. In the third plane these effects are more accentuated. In the far distance the bluish effect greatly increases, and all the colors melt more or less into blue: yellow takes a greenish tint; red, nearly violet; and blue, light blue if originally dark blue, or dark blue if originally light blue. But this blue should never surpass or contain more color than the blue of the sky, which is the blue of the atmosphere at its greatest intensity.

We will shortly endeavor to render in neutral tint these various effects of distance.

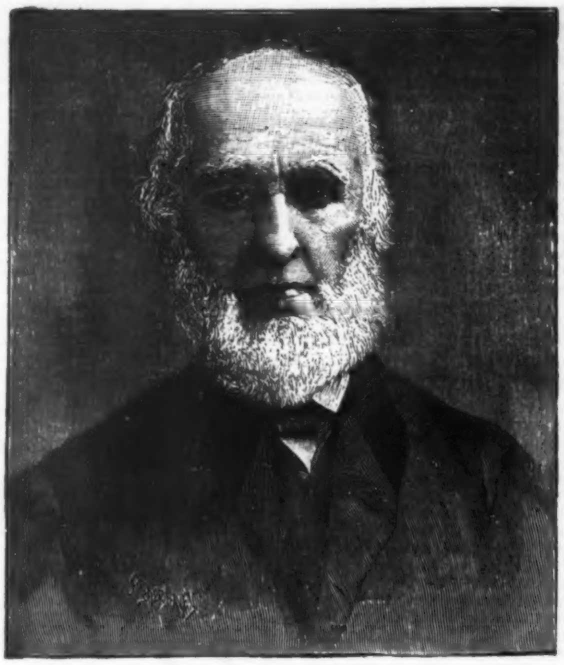
We have also to take into account the effects of contrast and irradiation. We know that if two surfaces, one colored black and one white, are placed together, the white appears whiter and the black blacker by the effect of contrast; and in two surfaces of an equal size, the white appears larger than the black; in fact, the light colors seem to encroach on the dark colors. This may be noticed when looking at a window strongly lighted from behind—the dark window bars appear narrower than they really are. A gray surface against white appears still more gray, and black against gray makes the gray appear almost white. Again, colors appear more intense when placed near their complementary colors. Two tints of green slightly different will mutually diminish the effect of one another; but the same green against red appears all the more intense. The same effect will be noticed with all colors and their complementary colors. If we placed any bright color against white, the white will gradually appear to be tinted with the complementary color.

All these effects should be introduced when necessary in an architectural drawing, and should be even exaggerated—the drawing will then appear effective. Of course, the student must combine method with taste, and a close study of natural effects. The windows of a building appear very dark, for the interior of a building is naturally less lighted than the exterior. The dark of the window should also contrast with the well-lighted wall surface. The roofs of a building appear appear dark, so as to be well detached from the brilliantly lighted sky. The shadows in a roof should appear very dark. The general tint of a building should gradually become more intense as it approaches the top; and the portions against the sky should appear tinted with orange, the complementary color of the blue of the sky. Therefore buildings of yellow stone or red brick should be graduated in color, the tint being more intense near the top, and slightly colored with orange or yellow against the sky.

Fig. 3 is an example of the effect of contrast, the surface, B, in shadow becoming gradually darker in tone as it approaches the lighted surface, A. In Fig. 4, the upper portion in shadow, F, should appear darker than the rest of the shadow, it being in contrast with the sky. The fine shadows of small mouldings, as at D, should appear very dark, and much darker than the large surface of shadow at G.—*Building News.*

JOHN GREENLEAF WHITTIER.

John Greenleaf Whittier, the well known American poet, who died on Wednesday, September 7, in his eighty-fourth year, was born on December 17, 1807, at Haverhill, Massachusetts. Like most other American men of mark, the blood of the Pilgrim Fathers was in his veins, his first American ancestors having emigrated from England in 1638. His family had long been of the Quaker persuasion, and it was as a Quaker, though of a somewhat advanced section, the Hicksite schism, that the poet lived and died. His early years were passed in work upon his father's farm, and he received but a simple education. Poetry, however, being one of those gifts which are hidden from the professors of Greek and revealed unto plowboys, was not long in finding him out. A copy of Burns, which fell in his way when he was about fourteen, is said to have put the match to his ambition. At eighteen he was sending liberation poems to Lloyd Garrison's *Free Press.* Lloyd Garrison was so struck with some of them that he rode some fifteen miles to Whittier's home to have a look at his young contributor.



JOHN GREENLEAF WHITTIER.

Thus was struck the keynote of Whittier's life—a life of song devoted to the service of freedom. His was not the "delight in singing, though none hear beside the singer;" he sang emphatically to be heard, because he had a simple, stirring message to deliver somehow, and song was the best way he had of delivering it. He had early put away any dreams he might have had of a *l'art pour l'art* existence, as he tells us in this forcible and beautiful little poem:

> God said, "Break thou these yokes: undo
> These heavy burdens. I ordain
> A work to last thy whole life through,
> A ministry of strife and pain.
>
> "Forego thy dreams of lettered ease,
> Put thou the scholar's promise by;
> The rights of men are more than these."
> He heard and answered, "Here am I."

Whittier, indeed, "heard and answered" with his life. From the starting of Lloyd Garrison's paper, the *Liberator*, he became prominently connected with the Abolitionist party, remaining its inspiring minstrel till

WHITTIER IN HIS STUDY, AT AMESBURY, MASSACHUSETTS.

the end of the troubles; though, as became one of his persuasion, his was not a battle song, but rather a fiery appeal to the dormant humanity of his fellows, *sacra fames libertatis*. Lowell was rather the Taillefer of the movement. Whittier was not satisfied with singing, he also edited the *Pennsylvania Freeman* in the interests of "liberation," with the result that the office was burned down by the mob, he himself barely escaping with his life; not by any means the only time in which he, a man of the sensitive literary temperament, faced personal peril for his opinions. On the burning of his paper, he returned to his birthplace, and, selling his family property, removed with his mother, in 1840, to the village of Amesbury, where he lived till his removal, in 1876, to his final residence at Oak Knoll, near Danvers, Mass. He never married. His life for many years has been passed in tranquil literary occupations, no little brightened by visits from his many admirers, for he has long been a venerated figure in America. After Longfellow, he was certainly the people's poet, as, indeed, with a necessary limitation, one may say of him in England, too. Especially among Dissenting people in the country districts you find his poems widely known and loved, and, of course, in the different sphere of the dramatic reciter, his ballads of "Maud Muller" and "Barbara Freitchie" are, so to say, classical. He was a very prolific writer. From the publication of his first volume, "Legends of New England," in 1831, he poured forth something like forty volumes, of which, in point of art, his "Snow-bound" (1862) is the most important. But it will probably be by his devotional poetry that he will be remembered.

Poets are but the articulate voices of certain temperaments. The greatest poets are supposed to appeal to all—though that is a dictum which cries out for a stern examination. However that be, Whittier spoke for the happy, simple temperaments of God-fearing, simple-minded folk, untroubled by "the burden of the mystery," undreaming of "decadence."

He was a good man, an earnest, unselfish citizen; and to these more important characteristics he added a considerable poetic impulse. There is a directness about much of his verse, an inevitableness of metaphor, which make one disposed to think that, had his life allowed him more opportunities of culture, had he lived more for himself and less in the service of his fellows, he might have been known as a daintier singer. But the time is happily passing when a cunning skill in meters is held to be more honoring than an honest, manly life. The poet, like many another oracle, is being found out. Whittier was a man, and that is more than many a poet of much better verse can say for himself.

Yet here at least an earnest sense
Of human right and weal is shown;
A hate of tyranny intense,
And hearty in its vehemence,
As if my brother's pain and sorrow were my own.

O Freedom! if to me belong
Nor mighty Milton's gift divine,
Nor Marvell's wit and graceful song,
Still with a love as deep and strong
As theirs, I lay, like them, my best gifts on thy shrine!

Surely Whittier was right in deeming love the one thing needful, the one thing most worth giving. As he gave he has received. The love of a great people is his monument. For the above, and for our illustrations, we are indebted to *The Illustrated London News*.

HOME OF JOHN GREENLEAF WHITTIER, AMESBURY, MASSACHUSETTS.

THE FIRST APPLICATION OF BROMINE.

The successful demonstration of Daguerre's process by Joseph Saxton, says Mr. Julius F. Sachse in the *American Journal of Photography*, together with the subsequent experiments by Robert Cornelius, had excited a widespread interest in the scientific circles of Philadelphia. Among the scientists who thus became interested in the new process was Dr. Paul Beck Goddard, assistant to the professor of chemistry in the University of Pennsylvania, who then resided or had an office on the east side of Ninth Street, opposite the university.

Dr. Goddard at once opened communication with Mr. Cornelius, examining the apparatus, and investigating carefully the manipulations as practiced thus far by the latter. These visits ended by a duplicate apparatus being made for the use of Dr. Goddard, who entered into a series of chemical experiments, in which it is stated that he had the assistance of the celebrated chemist, Professor Robert Hare.

It will be noted that thus far all the results shown by Saxton and Cornelius had been obtained by the use of dry iodine as a coating for the plates.

In the previous chapter it has been stated that the first two portraits ever made by the daguerreotype process were made by Cornelius—the first of himself, the other of his children, which is also still in existence. The honor of making the third portrait belongs to Dr. Goddard. This was also made in the open air in the rear of his residence on Ninth Street, by the use of dry iodine. The subject or sitter was a student in the medical department of the university—Aaron D. Chaloner. An interesting account of this sitting was given the writer by an old physician still living, who was present on this occasion, fifty-three years ago, while a student at the University of Pennsylvania.

The subject, Chaloner, was seated upon a chair in the bright sunlight, with the injunction not to move, but he became restless before even the preliminary operations, such as focusing, were completed. Dr. Goddard, fearing that the attempt might result in failure, obtained from Dr. Hare's laboratory in the university opposite a blue reflector of some kind, and after the focusing was completed, a blue reflection was thrown upon Chaloner by an assistant, in such a manner as to neutralize the direct rays of the sun. The exposure, it is stated, was prolonged to about three minutes, and resulted in a fair picture.

THE FIRST INSTANTANEOUS PICTURES.

The investigations and chemical experiments of Dr. Goddard were mainly confined to chlorine, bromine, and iodine, and he was not long in discovering that bromine, combined with iodine on the plate, would reduce the time of exposure from one-third to one-half within doors,* while in his yard, in the open air, the impression was almost instantaneous. These experiments resulted in the production of a perfect specimen by the use of bromine in December, 1839, which was subsequently shown at the American Philosophical Society (*Proc.*, vol. iii., p. 180).

This is the first record of the employment of bromine in the photographic process. It was during this series of experiments with bromine that Dr. Goddard succeeded in obtaining several good views and portraits instantaneously in the open air, which were the *first instantaneous pictures made by any heliographic process in the world*.

The application and use of bromine as an accelerator was kept a close secret by Goddard and Cornelius for about two years. It was this use of bromine, together with Cornelius' superior skill in polishing his plates, which accounts for the great beauty of his early daguerreotype miniatures. There is still in existence a plate,† unfortunately in a very dilapidated condition, which it is claimed was one of Goddard's earliest bromide efforts. It represents two male figures in a *neglige* attitude, one leaning back in a chair, the other against a fence. The picture was, without a doubt, made in the open air.

It has been stated to the writer by several old persons who knew Dr. Goddard well at that time, that for a short time he made for pay daguerreotype miniatures at his residence in Ninth Street. His appointment as demonstrator of anatomy in the University of Pennsylvania, in the year 1841, diverted his attention from professional portraiture. He, however, did not relax his interest in the new art.

In the latter part of the year 1841, a young man, an assistant to Cornelius, was approached and tampered with by parties from New York, who had opened a daguerreotype gallery there. This individual succumbed to the temptation of the offers made to him, and secretly left Cornelius and worked for two weeks in New York, divulging the whole secret of the use of bromine as an accelerator. As soon as this fact became known, Dr. Goddard at once published the discovery, and the process became public property, and soon came into general use. At a subsequent stated meeting of the American Philosophical Society, held January 21, 1842, Dr. Goddard presented specimens of photographic portraits made by the diffused light of a room, and by the peculiar process in which bibromide of iodine is used. This process he described, and stated that he had ascertained, only on that day, that a similar method had been presented to the French Academy, which, however, in some particulars was inferior to his own. (*Proc. Philo. Soc.*, vol. ii., p. 144.) On the March 4 following Dr. Goddard exhibited, before the same society, specimens of daguerreotypes on a surface of gilded silver, and stated that the surface of iodide of gold was more susceptible to the daguerreotype action of light than that of the iodide of silver, that the surface of the plate might be polished without injury before the action of the iodine, and that the lights came out better than on the silver surface (*Proc. A. P. S.*, vol. ii., p. 150).

In English and Continental text books upon photography, the claim for priority in the use of bromine as an accelerating agent is usually accorded to one John Goddard, a London optician. That this is clearly an error is apparent from the above indisputable record. The honor for the first use of bromine as a sure and valuable accelerator and the subsequent application to daguerreotypy and photography, without a shadow of doubt belongs to Dr. Paul Beck Goddard, of Philadelphia.

Paul Beck Goddard, a native of Philadelphia, was born in the year 1809, graduated in the medical department of the University of Pennsylvania in 1832, appointed demonstrator of anatomy for the same institution in 1841, a position which he resigned in 1847, when called to the chair of anatomy of Franklin Medical College, which he filled until 1852. In 1847 he was appointed surgeon to the First City Troop—Philadelphia's crack military organization. From 1859 to 1863, Dr. Goddard was connected with the Philadelphia Board of Health, from 1863 to 1865 he served as surgeon in the U. S. Volunteer Service. He died July 5, 1866.

It is further a noteworthy fact that, while Philadelphia scientists labored to shorten the time of exposure by chemical means, confining themselves exclusively to the Daguerrean apparatus, which time has proved to be the only practical method, experimenters in New York attempted to achieve the same object by the use of mechanical inventions and such chimerical apparatus as a reflecting camera, and other equally impracticable devices, which were all abandoned as soon as Goddard's Philadelphia process had been surreptitiously obtained.

* The laboratory of Dr. Goddard was lighted by a skylight.

† Now in possession of the writer.

[Continued from SUPPLEMENT, No. 877, page 14015.]

HISTORY OF ARTIFICIAL ILLUMINATION.

GAS LIGHTING AT THE PARIS EXPOSITION.*

Before the utility of raising the temperature of the flame was decided upon, it was a question as to whether it would be better to heat the air instead of the gas, or if it was sufficient to heat the air, and whether a new discovery would not be given by heating the gas alone.

Reason as well as experience answered. It is known that combustion to be complete requires about 6 volumes of air to one volume of gas: the temperature of the flame would then be greater by heating the volume of air instead of the gas; besides, the heating of the gas above a certain temperature becomes detrimental. A decomposition of the hydrocarbons can be carried, and the carbon thus put at liberty before arriving at the flame is deposited in the form of soot, injuring the apparatus, besides impoverishing the gas before it reaches the burner.

It was, as we have said, in 1879 that F. Siemens utilized the heat lost in the products of combustion for heating the air aiding combustion, and invented the regenerative burner, the patent for which was obtained in March, 1879.

The first type of the Siemens burner was composed of 3 concentric chambers in cast iron or bronze, surmounted by a burner. The gas reached the top by a series of small vertical tubes and met, at the outlet of these tubes, the air which passed through the lower chambers. The luminous sheet formed by the juxtaposition of the gas jets was inverted from top to bottom, by a lateral chimney draught around a cylinder of refractory material, entering the interior of the chambers above mentioned, which were carried to a high temperature by the heat regenerated from the products of the combustion, escaping by the lateral chimney at 600° or 700°. The air heats itself in coming into contact with the walls of the interior chambers, and attain a temperature of about 500°.

This burner was presented in France to the Society of Civil Engineers in January, 1881. The following table indicates the types constructed:

Number of Burner Tubes.	Consumption per Hour. Liters.	Luminous Intensity. Carcels.	Hourly Consumption per Carcel. Liters.
15	300	5 to 7	45 to 50
18	600	13 to 15	40 to 45
28	808	20 to 22	38 to 40
32	1,600	46 to 48	33 to 35

The Siemens was especially used in Germany and England, but the ungracious effect of the heavy shell constituting the regenerator, and the difficulty in disguising in a decorative fashion the lateral chimneys, prevented its being extensively used in France outside of a few workshops. In 1882, there were 4 lanterns provided with Siemens burners of 1,600 liters installed in the Place du Palais Royal, in Paris, and these were in operation about a year or two; the lanterns were considered too heavy, and finally the action of the wind was felt by the flame, notwithstanding the precautions taken, and the light was not always regular.

About the same time, the city of Paris established in a highway traversing the Champ de Mars two Siemens burners of 2,200 liters, raised by supports 40 meters above the ground, and placed in the interior of a curved reflector; these remained in operation until work was begun on the exposition.

In Germany the Siemens burner was largely used in the principal cities, especially for public lighting. Ger-

* Report of the Jury of Class 27. Translated by M. L. Dreher, for *Light, Heat and Power*.

many is about the only country where are still frequently found the old and ungraceful type of the Siemens burner.

In England, in 1882 and 1883, that is, but a little while after the Electrical Exposition at Paris, in 1881 (where the incandescent lamps made their first appearance), at the International Exposition of Gas and Electricity, in the Crystal Palace of London, gas and electricity competed for lighting the principal building of the Palace. The Siemens burner was produced on a large ladder, in competition with the high power burners without regeneration of Sugg and Bray, installed in enormous lanterns, such as we have noted: 16 Siemens burners of 60 carcels, consuming more than 2,000 liters of gas each, and a burner of 120 carcels, all suspended at a great height, lighted the extremity of the building. Notwithstanding the intense light, the effect left something to be desired. The principal inconvenience was the regenerator placed under the flame, which obstructed much of the light.

It was at the Exposition itself, at the Crystal Palace, that there appeared the first types of regenerative lamps with inverted flame, the regenerator above the flame, a disposition for which Francis Wenham, of London, took out a patent in August, 1882. This idea is very simple, adding to the principles of Chaussenot and Siemens, and constituting a very important improvement, actually putting into practice the high power regenerative burner. It is well understood that with the regenerator placed above the flame, the lateral chimney is dispensed with, and profit thereby secured without interference of all the light generally placed above the parts to be lighted.

From that time the high power regenerative burners with inverted flame were successfully improved, without modification of principle, by numerous manufacturers. Wenham, in 1884–85, began manufacturing on a very large scale, and turned out a considerable number of types of large and small consumption, most of which figured at the exposition, and for which he deserved a gold medal. We will also mention the Cromartie lamp, of Sugg (gold medal), manufactured in France by the firm Delafollie (gold medal); the gazo-multiplex burner of the Belgium Society of Lighting Apparatus (gold medal); Ezmos lamp; Gregoire and Godde lamps, called Rouennaises, Wouters, Danichewsky, Deselle, etc., speaking only of interior lamps; finally, the new Siemens lamp, with inverted flame, similar to the preceding ones, but presenting an exterior volume of gas superior to that of the Wenham lamp, the flame of which is thin.

Most of these lamps are very similar, the principle being the same, as stated before, and the difference being more in the details of construction. Some apply the regenerative principle at the top, others at the bottom; the latter system is to be preferred, for the reason given above; that is, to prevent the premature decomposition of the hydrocarbons, the least fixed and, at the same time, the richest, and not to place the conduit carrying the gas in the hot parts of the lamp.

There is also to be mentioned the lamps in which the flame is conducted from the interior to the exterior, and those in which, on the contrary, it spreads from the exterior to the interior, but, as we have previously stated, it is simply a difference in construction, and we will give but the summary indications of the organs which characterize them.

Wenham Lamp.—The regenerator is formed by two concentric cylinders, which are in three parts; these cylinders are put into communication by radiant horizontal tubes; the exterior air, passing under a sheet iron envelope, penetrates by the horizontal tubes into the interior cylinder, and from that to the burner, constituted by a perforated crown, similar to the Bengal burner; the flames expand toward a central cap in the shape of a mushroom; the products of combustion pass into the chimney in traversing the exterior cylinder and the horizontal tubes.

Cromartie Lamp (new).—The regenerator is composed of two cast iron cylindrical bells, the conducting gas tube is placed in the center; the air enters the exterior cylinder, heating the walls before going into the chimney. The regenerator is entirely of cast iron. The Cromartie lamps were especially constructed for small powers, and M. Sugg manufactured some lamps consuming but 2' to 3' per hour, being only 56 to 80 liters, giving 1½ to 2 carcels.

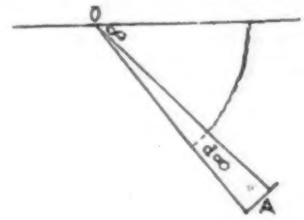
Gregoire and Godde Lamp (Rouennaise).—This burner, instead of being the inverted Argand burner, like the Wenham, is formed by a small hollow cylinder in steatite; the burner is screwed on an iron tube serving as a suspension valve, and is furnished in the interior with a glass tube, through which the gas passes; the gla tube has the effect of preventing the discharge in the burner of dust or metallic film which detaches fr. n iron tubes heated to a high temperature. The regenerator is of cast iron in a single piece.

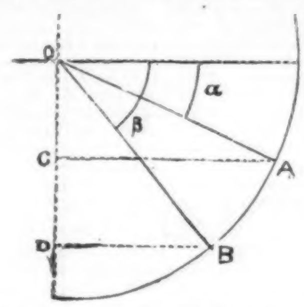
Siemens Lamp (new).—(The Siemens inverted regenerative lamp.) This lamp resembles very much the preceding ones, and the care taken in its details produces a remarkable effect by the stability and whiteness of the flame; several types were in use in the rotunda of the gas pavilion at the exposition. The ordinary models have a consumption varying from 250 to 1,250 liters of gas per hour.

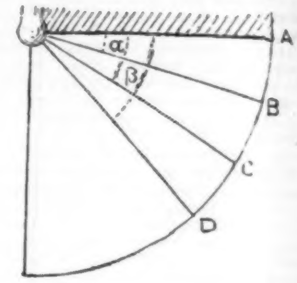
We also note a special type which differs from the others: The type with the flat flame, constructed with one or three flames, and which merits particular mention by reason of its simplicity. In this lamp, an ordinary horizontal batwing burner is placed in the closed section, as usual, below a regenerator, the lower surface of which is perforated, forming a reflector; the gas enters by an exterior tube without having been heated; the flat flame spreads under the openings of the reflector; the products of combustion pass out through a slit in the shape of an arc, and heat the regenerator; the air descending reaches the flame by traversing the perforations in the reflector. We have, therefore, a simple batwing burner, burning in heated air, and in good position to light the parts situated below it; the arrangement is simple; the burner is neither delicate nor susceptible of rapidly being soiled. It is constructed to use but a small consumption of gas. With a large batwing burner of 183 liters, experiments have given about 4 carcels, being 46 liters per carcel.

Gazo-multiplex.—The Franco-Belgian Society especially exhibited lamps of small caliber, called Gazo-multiplex. These give 2 carcels 45 with 180 liters of gas, being 52 liters per carcel, a remarkable result for such a burner. We especially note the experiments made on the burner at the gas pavilion laboratory, by M. Sainte Claire Deville. The burner has a tulip-shaped flame; the focus, placed in the center of a glass cup, sends its rays to the upper parts of the place to be lighted, and not only on the ground; the gas enters at the center of the cup, the alimentation coming from the bottom; the hot air issues from the regenerator above the gas flame.

Ezmos Lamps.—This lamp does not differ very much from the other high power lamps. The Belgian Society, which exhibited it, recommended it for its superior intensities, in preference to the Gazo-multiplex burner. It is of cast iron, its designer considering that this material, while resisting the action of the highly developed temperature, prevented the loss of heat, thereby regulating the system of combustion. A plaque of enameled iron is attached to the regenerator, forming at the same time a reflector, and having at its periphery a variable number of small holes, through which the air enters into the interior of the globe; the flame is guided by a sort of a guide made with the cylinder.







Deselle and Lebrun Lamps.—These lamps are on the same order, the recuperator is constructed in a very simple manner and is not expansive. The air is not heated as much as in the preceding systems, and circulates around the vertical tubes placed between two cylinders. The gas and the air enter one over the other from opposite directions, which has the effect of reducing the pressure of the gas mixture, a condition favorable to lighting power.

The Deselle lamp can be screwed on ordinary apparatus, like any ordinary burner; the combustion is obtained in the spherical ball, and the high parts of a place to be lighted receive, therefore, a certain quantity of light. The lamp being very simple, is also inexpensive.

Danichewsky Lamp.—This lamp is distinguished from all the others by its regenerator, which is of copper plate and forms a sort of plait; the air, after having circulated in the recuperator, enters into a central pipe, and descends on the burner. This burner presents a special particularity. It is composed of a simple tube opening into an open burner; a valve placed in front forces the gas jet to spread.

A new system of M. Danichewsky combines his burner in such a way as to permit the lighting of high parts of rooms; the gas enters by the upper part; the burner continues to be a simple tube, but a valve is used so as to give the flame a pronounced annular form; the air, after having traversed a hollow plug and a spiral plate, exits below the flame.

There still remain a large number of regenerative lamps: See Lamps, Westphal lamps, and others, concerning which it seems unnecessary to go into details; besides, further on, we shall discuss the types used for public lighting.

We simply recall that the essential conditions for a good working of regenerative burners are that the burner must be well regulated, that is, the proportions of air and gas admitted be calculated with precision, and also that the working of a good regulator or rheometer assures a constant flow of gas under all pressures.

We cannot often enough repeat that these conditions are essential, and miscalculations have been proved with certain regenerative burners for the very reason that these conditions were not noted.

If these essential conditions require care in the construction and attention in the use, they are more than compensated by the important advantages which we have shown.

We have now reached the most interesting point concerning the high power lamps: the measure of their luminous intensity, which is so often exaggerated by inventors and manufacturers.

To measure the intensities of the light emitted by luminous sources, somewhat powerful, like the regenerative burners, it would not suffice to take these measures in a horizontal direction; these sources have a lighting intensity differing according to the different directions of the luminous rays, and it is necessary to measure the intensities at different angles.

This study was made the subject of the greatest care for most of the burners previously described, for the types at least presenting no great intensity, during the exposition itself, at the gas pavilion laboratory, which was graciously put at the disposal of the jury of Class 27, with M. E. Sainte Claire Deville, as an able savant, assisted by MM. Salanson and Brisac. From their report we take the following:

"To begin with, let us state, summarily, that for these experiments there were used the Bunsen photometer and the Kruss mirror, movable on an axis passing through its center and making with its surface an angle of 45°; special mechanical dispositions permitted the burner to be maintained at a constant distance of the center of the mirror; the coefficient of absorption of this latter apparatus had, besides, been determined with care in a series of special experiments.

"The luminous intensity is a part pertaining to luminous elementary rays, and it is only by a fault in language, very frequently committed, that one can speak of the luminous intensity of a lighting apparatus. This confusion had no inconveniences as long as all the burners used appertained to the Argand type, or to a type of split open-air burners, because the apportionment on a sphere of ray 1 was about the same for all the apparatus, and the total quantity of light which was produced could be considered sensibly proportional to the intensity proper of the horizontal ray, or even that of any other ray, taken alone, which is absolutely insufficient to appreciate the total quantity of light emitted by the burner.

"It is this knowledge of the total quantity of light emitted which is absolutely necessary to introduce into the current language.

"Taking a luminous ray coming from the burner, O, and included between the limits of an angle infinitely small, $d\infty$, normally receiving on a screen, A, the light emitted by the ray considered, and removing the screen so that the element of the surface lighted presents to the eye exactly the same aspect as the photometric screen of Dumas and Regnault placed at one meter from the carcel lamp: R being the distance thus determined, the intensity of the luminous rays, OA, will have for measure, R^2. This settled, let us trace a sphere of the ray, R, having its center in O, and take it for granted that we have proved experimentally that all the luminous rays included between OA and OB possess the same intensity, R^2, as the ray, OA. All the quantity of light emitted by the burner between the limits, OA and OB, will be received on the zone of the sphere, AB, which zone shall be uniformly lighted, exactly as is the Foucault screen placed at one meter from the carcel.

"If we adopt as unity the quantity of light, under the name of superficial carcel, the quantity spread on one square meter normally lights to the intensity, I; that is, like the Foucault screen placed at one meter from the carcel, the quantity of light emitted by the burner between OA and OB, that is, in the angle, $\beta-\alpha$, will be equal at the surface of the sphere zone, AB. We have

$$Q\,(A + B) = 2\,\pi\,R \times CD;$$

or,

$$Q\,(A + B) = 2\,\pi\,R\,(R \sin\beta - R \sin\alpha)$$

This may also be read

$$2\,\pi\,(\sin\beta - \sin\alpha) \times R^2$$

that is to say, it is equal to the product of the surface of the zone, $\beta-\alpha$, in the sphere of the ray one, by the luminous intensity common to rays emitted in the angle ($\beta-\alpha$).

"Take a regenerative burner, emitting light only above the direction, A, direction corresponding to an angle of 15°, for instance, and directly measure the intensities. We will admit that the rays emitted between A and B have all the medium intensities of these two rays; the same for the rays between B and C, and so forth.

"From this we can calculate the quantities of partial light emitted in each zone:

$$Q\,(A + B) = 2\,\pi\,R^2\,(\sin\beta - \sin\alpha)$$
$$Q\,(B + C) = 2\,\pi\,R^2\,(\sin\gamma - \sin\beta)$$

"The sum of all these quantities will represent the total light amount emitted by the burner expressed in superficial carcel: that is, the number of square meters to which the burner is capable of simultaneously communicating a light equal to that of the Foucault screen taken as unity. It is also the same number which represents the total intensity at the surface of the sphere of the ray one.

"If we divide the quantity of total light by the consumption of the burner, we obtain the effective power, or the quantity of light produced by 100 liters of gas burning one hour in the burner. We can also consider, from a like point of view, the reverse of this; that is, the volume of gas necessary for giving to one square meter of surface the lighting result. These two numerical results measure the true value of the burner, in an economical point of view of the production of the light.

Name.	Consumption per Hour. —Liters.	Total Light per Burner. —Superficial Carcels.	Light Sent Above the Ground Line.—Per Cent.	Quantity of Light per 100 Liters per Hour. —Superficial Carcels.	Hourly Consumption per Superficial Carcel.—Liters.	Maximum Rays of Intensity. Direction.—Degrees.	Maximum Rays of Intensity. Max. Power.—Carcels.
Lebrun	155·3	18·73	79·6	12·06	8·29	60	2·733
Deselle	173·0	21·38	79·7	12·36	8·09	45	3·100
Wenham	166·0	20·06	86·7	12·08	8·27	30	3·097
Danichewsky (old)	179·0	27·03	85·7	15·10	6·70	45	3·928
(new)	162·0	22·04	70·84	13·60	7·35	45	2·715
Gazo multiplex	120·0	14·00	76·47	11·64	8·58	30	1·638
Cromartie (small)	87·7	10·53	82·91	12·01	8·32	45	1·536
(140 liters)	126·0	18·93	79·88	15·00	6·66	60	2·594

"Knowing the quantities of light in each zone and their totals, we will calculate, therefore, the apportionment (per cent.) of the light in the different directions.

"It is seen that the experiments thus shown furnish the absolute total quantity of light emitted by the burner, the cost of this light and its apportionment.

"The foregoing table is a *résumé* of these experiments.

"As shown, the total effective power in superficial

carcels, or the quantity of light per 100 liters of gas per hour, does not sensibly differ between the different burners considered—which do not take in, as we have said, large power burners; but in practical cases, it is not always the totalization of the light which is the most important, but rather the quantity of light sent in a determined zone. A judicious choice should be made between the different high power burners, according to the use they are to be put to, and the fraction of the total light emitted by a burner in determined directions is an element of the question which should not be neglected."

We stopped speaking of the burners used for public lighting at the progress made about 1878 by the high power regenerative burners.

The application of the invention of Siemens to city burners could not be retarded, and we have said how they were used, about 1881, in the different cities of Germany, and in Paris, in 1882, etc., and how the first experiments were defective.

There are, in fact, for public lighting apparatus, certain special conditions required, and it does not suffice to simply find the maximum luminous results.

The apparatus should be insensible to the action of the wind; it should, besides, be simple, need no watching, have but little attention, be of a robust construction; in a word, what should belong to an apparatus performing a public service, and in operation a great number of hours per year, 3,600 to 4,000 hours, according to the lighting schedule of the cities, with 13 and 14 hours of continued lighting during the winter months.

The conditions are difficult enough to fill with regenerative burners; the metallic pieces or refractories composing the regenerator and its accessories are subjected to very high temperatures, so great that the air burning attains nearly 500°, with the products of the combustion escaping at about 500°, and this during a considerable number of hours, much greater than the average necessary duration of an interior lighting burner. All these apparatus have glass globes, being somewhat expensive (2 to 3 francs), and which, exposed to the wind and rain, necessitate frequent replacements.

These difficulties show why the current application of the regenerative burners for public lighting was retarded, and not established until after prolonged experiments.

It was, therefore, after the suppression of the old type of Siemens burners in the Place of the Palais Royal that 18 new Siemens burners were installed in July, 1883, in the Rue Royale, which were in operation about one year; but it was again necessary to replace them with others, on account of the difficulty in regulating the flames, and the frequent formation of lamp black, which obstructed the light, and rendered the care of the lamps both difficult and onerous. About this time, however, there appeared a regenerative burner, specially intended for public lighting, which had been patented in 1882, by Schulke, and which is now called the Parisian burner (system Schulke), and constructed by the Society of Improvements for Lighting.

The apparatus is composed of a series of vertical split burners in steatite, mounted on a central chimney disposed in a glass globe hermetically sealed. The regenerator is formed of a sheet of plated nickel, having the general shape of a frustum of a cone. This disposition is for the purpose of increasing the surface of the regeneration under a small volume. In the interior of the regenerator is a conductor, in nickel, which guides the products of the combustion; the burning air enters at the top of the regenerator and goes through all the external vertical flues formed by the plaited tube and its envelope; the products of combustion go up vertically, licking the walls of the plaited tube, which is brought to a cherry red, and unite in the base of the chimney, through which they escape while maintaining the draught; the exterior chimney is provided, in the lower part, with entrance orifices for air, and in the upper part with orifices of escape. The application of this chimney is for the purpose of preventing the fluctuation of the flame by strong winds.

The Schulke burner, which had been tried without success in 1884, in the Boulevard de la Villette, became, after successive improvements, and especially after the manufacturers abandoned the system of heating the secondary gas, an economical apparatus for public lighting and remarkably intense; the cost is still somewhat high, but the effect is very satisfactory, and the care has been much diminished with the constant improvements made within a few years.

The Schulke burner began to be much used in Paris about 1887; burners of 750 liters give a lighting power of 17 to 18 carcels, being 40 to 45 liters to the carcel. In 1888, 16 new lanterns of the same system, of varying consumption, were established in the district of the Halles, Rue Etienne-Marcel, etc. Finally, in 1889, 117 burners of 350 liters were established on candelabra of 3 branches, in the Rue de la Paix.

The different models of the Parisian burner consumed 225, 350, 550, 750, and 1,000 liters of gas per hour; the Society of Improvements of Lighting, and M. Bardot, who exhibited the principal types of these burners at the exposition, received silver medals.

Industrial Burner.—This burner, patented in 1888, by MM. Lacaze and Cordier, and constructed by the firm Bengel, presents a great similarity to the preceding burner. The regenerator is also in nickel, a metal which is well known to ably resist the heat, and is essentially composed of two vertical cylinders communicating by a series of horizontal tubes. It is especially the construction and the small height of the recuperator which causes the difference between the Industrial and Parisian burners; we also note the form of the glass globe, which is almost spherical, and not cylindri-spherical, as in the Parisian burner; this arrangement is for the purpose of removing the flame as far as possible from the globe, in order to diminish the danger of the globe breaking from the force of the heat.

The city of Paris installed, in 1889, 15 industrial burners of 750 liters on the Place des Victoires, and continued their use in other districts.

The 3 principal types constructed by the firm Bengel, which merited a gold medal, were those consuming 430, 750 and 1,200 liters per hour.

Guibout Burners.—The disposition of the burners is also very similar to the others, and the differences, very perceptible this time, are in the regenerator, which is composed of a hemispherical globe of refractory earth, placed in the center of a conoidal frustum, also of refractory earth; this system is for the purpose of preventing the more or less wear of the metallic regenerators. The two principal models constructed by the firm Giroud consumed 550 and 1,200 liters of gas per hour.

These burners were principally applied in the Avenue de l'Opera, where they were installed in 63 candelabra of three branches.

The following table is a *résumé* of the principal results of the burners just reviewed. We have placed at the head, as a point of comparison, the ordinary type of city burner:

Name.	Consumption per Hour. Liters.	Power of Light. Carcels.	Consumption per Carcel Hour. Liters.
Batwing (city)	140	1·1	127
4 Septembre	1,400	13·0	105
4 Septembre (Exposition type)	4,500	80·0	56
Siemens (old)	800	20·0	40
(old)	1,600	42·0	38
Parisian (Schulke system)	350	6·7	52
	550	12·6	44
	750	17·4	41
	1,000	25·2	40
Industrial (Lacaze and Cordier)	425	8·5	50
	750	18·1	41
Guibout	550	10·0	55
	1,200	27·0	44

From the examination of this table it may be concluded that with regenerative burners of types commonly used, the carcel can be obtained with a consumption of 40 to 50 liters of gas per hour, which represents an economy of more than half of the former results. It is understood, with these conditions, that the greater number of the cities which voiced the general sentiment of the insufficiency of the light distributed on the public highways (in Paris, the surface of the streets and places, 16,000,000 square meters, receives in public lighting apparatus a total of 80,000 to 85,000 carcels, being only 0·005 carcel per square meter, or even one carcel for 200 square meters, favor more and more the intense regenerative burner, since the practical difficulties under which it worked have almost entirely disappeared. The ordinary high-power burner increased the quantity of light, but the consumption was still considerable, and, finally, the economy could not be obtained, with the increase of lighting power, excepting by the application of the principle of regeneration. Therefore, for lighting ordinary highways, the batwing burner can certainly continue to be adopted, but for lighting cross roads and large public places, the use of the high power regenerative burner is found to be more satisfactory to the needs newly created by the introduction of the electric light.

We give some of the large installations recently made on the public highways in Paris, with a few numerical results relating to each:

Place de la Bastile.—Thirty-three industrial burners of 1,200 liters and 9 of 750 liters.

Total surface lighted	27,384 sq. meters.
Number of carcels	1,250
Consumption of gas per hour	46,350 liters.
Illuminating per square meter	0·045 carcel.

Rue du Quatre Septembre.—The open air burners of 1,400 liters, giving 13 carcels, which were used for the first time in that street, in 1878, were replaced by 34 regenerative burners of 750 liters, giving 17 to 18 carcels; there was a considerable increase in the light and a considerable decrease in the consumption of gas, and these figures bring out the progress made since the preceding exposition.

Rue de la Paix.—The Rue de la Paix was normally lighted by 39 candelabra of 3 branches, each carrying a burner of 140 liters, with an intensity of 1 carcel 1; this installation was replaced by 117 Parisian burners, Schulke system, of 350 liters to 6 carcels.

L'Avenue de l'Opera has 189 burners of 140 liters, for 1 carcel 1, and 7 of 1,400 liters for 13 carcels; the former were replaced by 187 Guibout burners of 550 liters for 11 carcels, and the latter by 7 Guibout burners of 1,200 liters for 27 carcels.

The comparison between the new and old lighting is as follows:

Rue de la Paix. Surface = 5·155 Square Meters.

	Old Installation.	New Installation.
No. of burners	117	117
Power	1 carc. 1.	6 carc.
Consumption	140 lit.	350 lit.
Total power	128 carc.	702 carc.
Total consumption	16·380 lit.	40·950 lit.
Light per square meter	0 carc. 025	0 carc. 138
Comparison of light	5·45	
Comparison of consumption	2·5	
Advantage	2·2	

Avenue de l'Opera. Surface = 20,940 Square Meters.

	Old Installation.	New Installation.
No. of burners	189	189
	7	7
Power	1 carc. 1	11 carc.
	13 carc.	27 carc.
Consumption	140 lit.	550 lit.
	1400 lit.	1200 lit.
Total power	298 carc. 9	2·268 carc.
Total consumption	36·260 lit.	112·350 lit.
Light, per square meter	0 carc. 014	0 carc. 108
Comparison of light	7·5	
Comparison of consumption	3·09	
Advantage	2·45	

It is interesting to compare the lighting now obtained with the lighting by electricity; taking as example the Rue Royale, which is lighted by 25 electric lights of 50 carcels, with the globes, we have:

Surface	10,500 square meters.
Carcels	1,250 carcels.
Carcels per square meter.	0 carcel 12.

The figure 0 carcel 12 is midway between the two given above; it is seen that the quantity of light furnished by the gas and electricity has become very close.

If the cost is compared we have, with the actual price 0·45 fr. per electric hour, and that 0·13 fr. (0·15 fr., less 0·02 fr. for tax) for the gas, the following results:

Electricity.

$$\text{Carcel hour, } \frac{0{\cdot}45 \text{ fr.}}{50} = 0{\cdot}0090 \text{ fr.}$$

Gas.

$$\text{Rue de la Paix, carcel hour, } \frac{40{,}950}{702} \times 0{\cdot}13 \text{ fr.} = 0{\cdot}0075 \text{ fr.}$$

$$\text{Avenue de l'Opera, carcel hour, } \frac{112{,}350}{2{,}268} \times 0{\cdot}13 \text{ fr.} = 0{\cdot}0064 \text{ fr.}$$

This example is very significant, and shows plainly the efforts made by the gas industry since the last exposition to maintain its place on the public highways, at the side of its brilliant rival, which has nevertheless attained a special position acknowledged by all, and especially effecting a general development of light.

The high power regenerative burners used for interior lighting equally as well as for public lighting show a marked progress, a progress which completes itself by the utilization which can be rationally made of the ventilation obtained in an automatic manner.

Of course, evacuation flues have to be reserved in the ceilings, but the modern construction of iron is specially adapted for these purposes, and the complication is not apparent.

The exposition of the gas pavilion had installed, in most of its luxurious apartments, ventilating apparatus, furnishing example and model; we could mention many other instances in Paris and in provinces, and certain colleges, academies, working establishments, etc., having very simple types of special apparatus for lighting and ventilation by gas, in rooms in which are a great number of persons; dormitories, studies, etc.

It is in these conditions, that is to say, with exterior escape chimney, that the regenerative burners really yield all their value, simultaneously effecting the two operations of lighting and ventilation, and not permitting any products of combustion to remain in the atmosphere, an inconvenience heretofore to the gas apparatus.

(3.) *Incandescent Gas Lamps.*—These lamps, as we have said, utilize the calorific power of the gas to carry to a high temperature certain solid bodies which become incandescent.

The first incandescent lighting which was applied is that known under the name of Drummond light. It was composed of a stick of lime brought to a red heat by a blowpipe of illuminating or pure hydrogen gas.

After the Drummond light there appeared the Tessie du Motay burner, in which the illuminating gas was burned by pure oxygen.

In actual use, there remain but two incandescent burners:

Clamond Burner.—Invented in 1880, by M. Clamond, and which is constituted by a basket of magnesium filament with metallic oxides, carried to incandescence by means of a Bunsen burner.

The gas, after having traversed a rheometer, arrives in a cup made of pottery; the air enters the interior and exterior of the crown which carries the magnesium basket.

The two inconveniences of these burners are fragility of the basket and the heat produced; in a new style of basket, certain arrangements of glass attenuate the rays, and these faults are notably diminished. However, the Clamond burner has also recently established a regenerator and reversed basket; the effect thus obtained very much surpassing that obtained by the first disposition, and permitting greater intensities, comparable to those of the small voltaic arcs. The firmness and whiteness of the light are remarkable.

Auer or Welsbach Burner.—This is composed of a Bunsen burner constructed in such a way as to operate the mixture of gas and air in the proportion of 8 liters 88 of air to 1 liter of gas.

The Bunsen burner heats a wick of zircon, mixed with oxides of lanthanium, didymium and others, the inventor guarding the secret. A mantle of cotton is soaked in a solution of the metallic oxides given above, then burned; there remains but the skeleton of the mantle formed by the incombustible oxides, which becomes incandescent under the action of the combustion of the gas.

The light of this burner is firm and agreeable to the eye. The heat developed is small. When the mantle is new, the carcel can be obtained with 23 liters of gas; but the effective power diminishes with the wear of the burner—a fact which is also found in the incandescent electric lamps; and the experiments of M. Sainte Claire Deville have shown that the intensity measured of 2 carcels 92 with the new mantle fell to 1 carcel 41 at the end of 250 hours. This burner has improved and still improves. Such as it is, the Auer burner is of a nature to render good services and is well adapted for an office lamp. A burner installed in the smoking room of the gas pavilion operated in a remarkable manner nearly all the time of the exposition. The burner received a silver medal.

(4.) *Carbureted Gas Lamps.*—The type of the carbureted gas lamps is the burner called albo-carbon, which is nothing more than a carbureter at the burner. The gas, before arriving at the burner, traverses a ball full of purified naphthaline pieces (called albo-carbon), heated from the burner itself, and arrives at the burner being carbureted to a state of rich gas. The flame thus produced is very bright, and the increase in lighting power is notable.

The inconvenience of these lamps is the odor of the naphthaline, which it is very difficult to entirely remove.

The albo-carbon burner, consuming 107 liters of gas, gives a light equivalent to 3 carcels 53, and consumes 7 grammes of albo-carbon per hour; for one carcel there is needed about 30 liters of gas and 2 grammes of naphthaline. The burner received a bronze medal.

There is with these types a reservoir which has to be fed (albo-carbon) or a mantle which has to be renewed (Clamond, Auer, etc.), whereas with the regenerative burners, as with ordinary burners, there is a continual flow of gas, without any adduction, ready to use at all times and perfectly simple in operation.

To resume, the number of improved burners which we have examined shows all the resources which gas, properly employed, furnishes for interior as well as for exterior lighting, and they attest the progress realized in the utilization of gas since the last universal exposition of 1878.

Heating by Gas.—The general question of heating is treated in a special part of the Report of Class 27; we have, however, something to say here regarding the application of illuminating gas for heating.

This application has constantly increased since the last exposition, and it can be said that, at the present time, the consumption of gas for heating in France attains nearly one-fourth of the total consumption; also, this proportion has been surpassed in certain cities, principally those where the gas is furnished at a reduced price for this purpose.

The conveniences of heating by gas, and especially cooking by gas, are well known. With the gas, the necessity of housing all combustibles is done away with, the heating is instantaneous, regulated as wanted, etc. The employ of gaseous combustibles piped is as simple and easy as the piping of water in the houses; besides, in a general manner, it can be said that modern civilization in the cities will demand this piping, either one way or another, for lighting, heating, and even perhaps for power.

Cooking by Gas.—Reviewing first of all the apparatus or stoves designed for cooking by gas, we find that, since 1878, there have been no remarkable improvements.

At least in France, the stoves have remained of a nearly uniform type. The burners of the stoves are always formed by crowns, the upper one pierced with vertical holes, through which the gas escapes; the crowns are generally of blue flame; the mixture of air and gas operates at the exterior part of the stove by means of an injector similar to that of the ordinary Bunsen burner; the row of grilles and roasters are composed of burners with a white flame. In England, on the contrary, the blue flame gas only is employed for the grilles and all the heating apparatus.

A French manufacturer, M. Bugnod-Garnier, exhibited stoves with self-regulating cocks; as soon as the cooking pot is raised from the stove, the flame immediately lowers, thereby preventing the waste which is the veritable enemy of the use of gas in the kitchen. This ingenious disposition was made several years ago by M. Serment; the difficulty in its application consists in obtaining an air-tight fastening to the entrance cock of the gas, by means of a direct lever.

The English manufacturers, principally Fletcher (gold medal) and Wilson (silver medal), exhibited their chief types, which differed somewhat from the French types. The injectors have orifices much larger and further apart from the point where the combustion of the mixture is effected.

These burners have the advantage of being easily cleaned.

Outside of the above, we have the results of numerous small types of stoves, grilles, etc., furnished by the manufacturers, and also their extreme cheapness, especially since the gas companies have purchased them in large quantities to furnish to consumers, either gratuitously or by renting.

As to the large stoves for hotels, restaurants, hospitals, etc., these are not much used in France, but their use has greatly developed in other countries, especially in England, on account of the low price of gas, consequent upon the perpetual grant practiced in that country.

Bath Heaters.—These heaters constitute a class of special apparatus of an importance much less than cooking stoves, but which have, however, their worth.

The firms of Viellard, Bengel, Barbas, Fletcher, Sugg, etc., exhibited types very superior to those of 1878. In 1878, the bath heaters were of a type often called "Geyser." The cold water entered like a fine rain; it was traversed by the flame and the products of combustion, and fell back warm, like the waters of the geysers. In actual type of Viellard the water is contained in an annular space between two concentric cylinders; above the center are rows of plates in which the water circulates, plates with the edges turned up, and finely perforated, through which the water passes, going from one row to another. We will also mention the bath heater of Doulton, in which the heated gases are not mixed with the water.

The improvements made since 1878 have permitted increase in rapidity in heating the bath, which can be done in less than 20 minutes with the best apparatus, and with a consumption of 750 to 800 liters of gas. It is also well to remark the improvements made in the cocks, in which the simultaneous maneuvers for water and gas take away all danger.

We will mention, as coming into the category of bath heaters, the apparatus for hot water, called "Rapides," giving hot water continually, and specially used for toilet, etc. It is composed of a hollow cylinder, with small wings, traversed by a current of water and placed above a row of gas jets; the entrance of the gas and water is moderated in order to obtain the desired temperature.

Heating of Apartments.—In this application of gas is found, since the last exposition, notable progress, due especially to the rational studies of the general conditions of heating by gas, which we think is a subject well worth speaking of.

It is necessary, in fact, to remember that the heat is transmitted principally by two distinct modes: the convection and the radiation.

The heat by convection is that transmitted by a solid body or a fluid, the particles of which are put in movement under the influence of a change of temperature.

The heat transmitted by radiation is that proceeding from the emissions of the calorific rays by the hot body, an emission which is effected at a distance.

We will give the following examples: a calorific which furnishes the hot air heated by convection; the sun heats by radiation; an ordinary chimney almost exclusively heats by radiation; an open fireplace heats by convection and radiation at the same time. Heat by radiation is, in a hygienic and comfortable point of view, to be preferred to that of heating by convection. The radiant heat will warm the habitants, the walls and furniture, without heating the ambient air, and it is well known that cold air is more healthful to breathe than warm air; volume per volume, it contains more oxygen, etc., and also, in heating the walls, furniture, etc., instead of the ambient air, it prevents these, by exchange of temperature, from taking the heat from the human bodies. The indications of the thermometer only are not sufficient in matters appertaining to heating an apartment; account must also be taken of the effects of the radiation, which the thermometer does not properly indicate.

Therefore, heating by radiation is to be recommended excepting that heating in this manner is less economical than heating by convection; in the former case, the heat is not so well utilized, and it is necessary, for practical usage, to employ methods giving heat both by convection and radiation at the same time.

It was for this purpose that the manufacturers have contended, especially the English manufacturers, since the last exposition.

In 1878, the gas heating apparatus for apartments were reduced to three kinds:

Open fireplace.

Apparatus with reflectors, invisible fire.

Gas stoves, invisible fire.

The open fireplace still sometimes used produced a radiant heat, and had the advantage of furnishing a bright hearth, but the product was weak, and the consumption of gas great.

The apparatus with reflectors is composed of a row of gas jets burning in front of a large reflector throwing back the light and heat; this arrangement is rather agreeable to the eye, and utilizes the gas better than the preceding apparatus, on account of the small proportion of heat by convection; the difficulty sometimes found with it was that it gave out an odor, but this was generally found to be the fault of not having an escape chimney.

The gas stoves are composed of metallic envelopes, generally of sheet iron, in the interior of which are arranged burners of different systems, in which the heat is utilized either directly or by passing the products of combustion through a series of tubes which furnish the heat of convection. In these conditions, the utilization is good enough, but it is absolutely necessary, except in outdoor places, to attach an escape tube for the burned gases.

Such were the apparatus in 1878, and such were still used in the later years.

The new models were of English type, created about 1882 and 1883 by M. Fletcher, of Warrington, and known under the name of incandescent fires.

We will give three types:

The first was composed of an iron chimney framing a refractory piece having its surface trimmed with a small flat asbestos covering. A row of gas jets burning blue, placed at the lower part, carries the refractory piece and the asbestos to a red, and gives the radiant heat.

In another series of types, the asbestos is replaced by fine branches of iron cast very thin, offering sinuosities similar to those of a coral branch; the iron branches are carried to a red and furnish an excellent radiance, superior to the preceding apparatus.

In a third type, the iron branches were replaced by hollow balls in refractory earth and asbestos, perforated in the shape of a bell, and arranged like coke in a foyer; this type very much resembles that created long ago, by the Parisian company, but which never succeeded very well. The ball type gives more heat than the others.

Finally, we will give the condensing stove, still little known in France, and which heats by convection and operates with an escape pipe. The contrivance which permits, in this particular case, the doing away of the escape pipe consists in condensing the water formed by the combustion of gas; this water wets the interior walls of the condenser, and retains by dissolution the injurious products of the gas of combustion, in a manner that only water, azote and carbonic acid comes out of the apparatus. The harmlessness of these stoves permits their being used to heat small conservatories.

Speaking of particular types of stoves, it is well to mention the stove exhibited by M. Potain, which takes the air outside of the apartment; a part of this air passes through a lower tube, aiding the fire center, which is composed of several batwing burners; the products of combustion rise in the exterior cylinder forming the body of the stove, from there escaping by a special pipe in the exterior atmosphere; the air destined to heat the room is also taken exteriorly and penetrates the central cylinder, in which it is warmed before entering the room. The stove is also interesting as a ventilating apparatus.

We will close this report by adding that all the gas stoves of which we have spoken have become for some time the object of incessant improvements; there is a tendency to utilize the products of combustion for heating by convection, by the use of envelopes with circulation of air; in fact, the best dispositions are tried for utilizing the gas for heating, as in gas lighting. The excellent principle of recuperation (Siemens, Foulis, Fletcher in England, Clamond in France), which would take too long to describe.

However, the progress recently made renders further developments certain.

COLOR.*

By President HENRY MORTON, of the Stevens Institute of Technology.

THIS evening I propose to talk to you on the subject of color. It has some very interesting relations which I want to bring before you, and possibly, before I get along very far, you will think I have mistaken the title and ought to call this lecture Paradoxes, because I shall have to tell you a great many paradoxical things about color, and show you, in a sense, paradoxical experiments; but I hope to make the matter clear to you, and show you the truth that lies in the paradoxes or statements.

Color, physically considered, is synonymous with wave length, light being composed of minute undulations or waves, varying in length from the 1-35,000 to the 1-60,000 of an inch, the former being the length of the red and the latter of the violet wave. These waves strike the eye with a velocity of 185,000 miles per second. Nearly 200,000 miles of them, therefore, enter the eye in every second, and every inch of these miles contains between 35,000 and 60,000 little waves. The whole number in a single ray is so enormous that it conveys no impression to our minds. Counting five every second, day and night, it would take about three millions of years to count what the eye receives in a single second. Yet the eye, when perceiving colored objects, not only takes cognizance, in some mysterious way, of these rapid motions, but even distinguishes their rates of velocity. Between the rates of motion of the colors at the extremities of the spectrum there might be an infinite number of intermediate rates, and hence of intermediate colors and shades. Evidently, however, the eye is incapable of discriminating more than a very limited number; and this brings us to the consideration of the eye itself, and the means by which we perceive color.

Fig. 1 exhibits the general structure of the eye. It

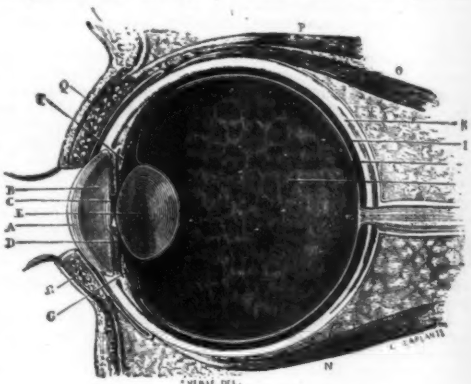


FIG. 1.

is like a photographic camera, or dark chamber, with its lens in front and a sensitive plate behind; only, instead of being coated with collodion, the sensitive part is a hollow sphere, covered with a delicate network of nerve structures, called the retina, which it is well worth our while to examine a little more in detail.

Fig. 2 shows the layers of the human retina magnified 400 times. There are no less than ten of them, all of which, with the exception of the two terminal ones, are made up of nerve tissue and connective substance. As the figure stands the light enters from the bottom. The vibrations communicated to the nerve substance finally reach the ninth layer, where experiments—which it would take too long to describe here—have led investigators to believe that the sensation of sight is located. This layer, called the "rods and cones," from the shapes assumed by the optic nerve substance

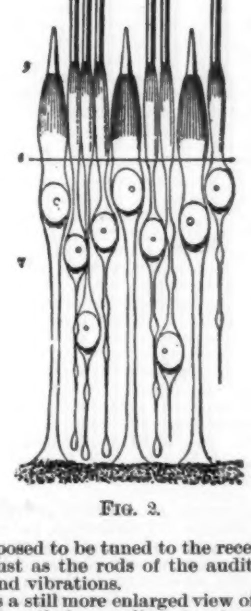


FIG. 2.

there, is supposed to be tuned to the reception of color vibrations, just as the rods of the auditory nerve are tuned to sound vibrations.

Fig. 3 gives a still more enlarged view of the rods and cones, showing their peculiar structure much more plainly. Each of them is in communication with a so-called granule, forming an enlargement which contains a nucleus. In life the granules are entirely transparent. Professor Max Schultze says: "The rods and cones must be considered the nervous terminal organs of the optic nerve. In them must take place the translation of the action of light into nervous action, which process ultimately lies at the foundation of the act of vision."

On still further magnifying these curious organs, it will be seen from Fig. 4 that even they, minute as they are, are divided into still more minute parts. What the functions of these ultimate parts are we cannot tell; although we have reached the extreme end of the optic nerve, and have seen its wonderful complexity, we can only reason that the conversion of light into sight must take place here, but we do not seem to have approached a knowledge of how it is accomplished by

* Lecture delivered under the auspices of the Carriage Builders' National Association, at the Technical School for Carriage Draughtsmen and Mechanics, New York City, March 9, 1892.—*The Hub.*

a single step. The whole subject lies far out in the *terra incognita* of science, and it is only intended here to state the problem as it stands at present, and to show through how tangled a jungle the path of knowledge lies in this direction.

Passing now from the anatomical considerations of the subject, we will examine the theoretical view proposed by Thomas Young, and more fully developed by Helmholtz. According to this theory, the eye perceives

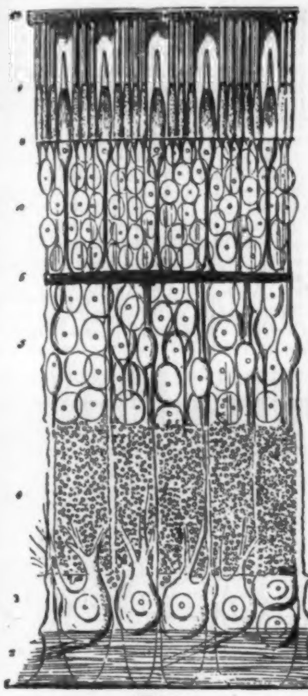


FIG. 3.

originally but three colors or wave lengths, and all the other colors and shades known to us arise from the compounding of the primary ones in the eye. Accordingly, we assume that the eye has three sets of nerves—one affected by red, another by green, and a third by violet. In other words, the nerve for red is tuned to vibrate to red waves of light, just as a tuning fork is set in vibration by communicating with a body sounding its note; and so with the other nerves.

Each of these nerves, however, is capable of being affected, though in a much inferior degree, by colors belonging to the others. Thus, the red nerves would be somewhat sensitive to green waves, but would perceive them as a faint red. If, for example, we look at blue light, whose rate of vibration is intermediate between green and violet, it will affect the green and the violet nerves, producing a mixed impression, which we call blue.

Let us try and prove this. If blue is to the eye

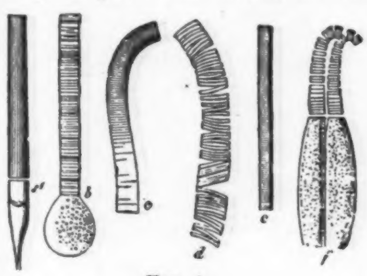


FIG. 4.

simply the result of a combined impression of green and violet, then, by exciting both the green and violet nerves by means of the corresponding colors, we ought to get a perfect impression of blue; but if the eye recognizes blue as a distinct thing, then a mixture of green and violet light will give the impression of something not identical with blue.

The lecturer then threw two disks of light on the screen, one violet and the other green; where they overlapped, as represented in Fig. 5, the result was a beautiful blue. Similarly, red and green disks of light, thrown on the screen, produced the compound impression we call yellow, Fig. 6.

FIG. 5.

FIG. 6.

It may be asked, however: Is not blue, being an intermediate wave length between green and violet, in fact their true average and equivalent? To show that this is not the proper manner of considering the question, it is only necessary to look at the manner in which waves combine. In the engraving, Fig. 7, we have two waves, one twice as long as the other, and below them is their resultant, obtained as follows: Both waves, starting at A, pass up in the same direction; their combined effect is therefore equal to their sum, which is represented at the point 1 below; again, at the point C the effect of the motion of one curve below the axis, A X, is diminished by the motion of the other above the axis, the resultant point being their difference in height, and on the same side of the axis as the greater. This point is represented at J. By combining in like manner all the corresponding points of the two curves, the resultant curve, given below, will be produced; and this curve certainly does not look like the average wave of the two, being, in fact, a very different kind of motion from either of its constituents.

But to follow out the consequences of Young's theory.

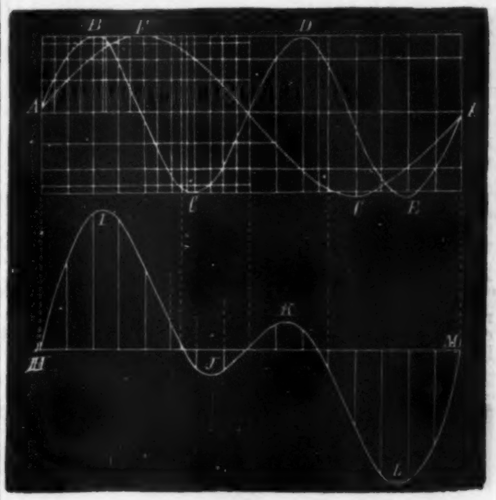


FIG. 7.

Although white light, as we know from the prism, is composed of all colors, the eye directly perceives but three of them; therefore, if we take these three colors and present them at once to the eye, the effect ought to be white.

The lecturer then threw on the screen disks of green, red and violet by means of three lanterns. Where all three overlapped, the result was white; where red and green combined, the result was yellow; and where green and violet combined, the result was blue, thus satisfying the requirements of Young's theory, Fig. 8.

FIG. 8.

Now, in this connection I want to draw your attention to another very curious effect that came out accidentally just now; that is, what we know as subjective color. If you present to the eye one color strongly for a few moments, and then the eye is turned on a white sheet of white paper, you will see, not that color, but you will see on it what we know as complementary color. For instance, after looking steadily at the red light for a moment, if you turn it upon the white screen you have got a green; or if you look steadily at a green light, and then look at a white screen, it has the appearance of a red one.

I have shown you now how I can mix colors on the screen to produce certain effects. Now, I propose to make the experiment in which mixtures will be made in your eye, and in accomplishing this it will show you another peculiar property of the eye. If a bright impression is produced on the eye, it will last about one-tenth of a second after that impression is gone. When an image is presented quickly to the eye and then withdrawn, the eye retains the impression for a short time after the actual image has ceased to exist on the retina. This is the phenomenon known among physicists by the name of persistence of vision.

To illustrate this property, which was soon to be employed in elucidating the theory of colors, a series of dots, moving forward and back like shuttles, was thrown on the screen. As the velocity of their motion was increased, the impression made by each of them, at every part of its course, remained on the retina long enough to allow it to come around again and refresh the memory, thus seeming to describe continuous

FIG. 9.

wreaths of light. A very beautiful effect was produced on the same principle by having a large revolving disk, with globes in different positions with regard to hoops painted upon it, illuminated with flashes of intermittent light produced by revolving before the source of light a disk of pasteboard with a number of slits cut radially on it. The large disk seemed to stand still, and the balls to roll through the hoops with great rapidity.

The principle of the persistence of vision may be applied to obtaining the blending of colors upon the retina by presenting them in quick succession to the eye. Professor Rood's chromatrope is an instrument for effecting this. It consists of a disk of glass, clear at the center, opaque in the shaded parts, and colored green and violet, as indicated by the letters in Fig. 9. On revolving this disk rapidly there was an outer zone of green and an inner zone of violet: but between them, where, by its revolution, green and violet are presented successively, the impression of green remained long enough for that of violet to combine with it in the eye, and to produce a zone of blue. Disks with other combinations of colors were also shown.

The most interesting illustration of the evening was presented by means of an apparatus invented by Professor Morton, which is well worth studying. An opaque disk, with W, Fig. 10, for a center, is made to

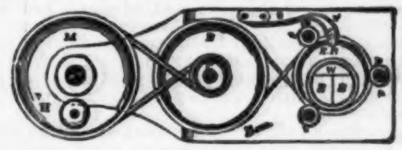


FIG. 10.

revolve before a lantern by means of the large pulleys M and P. It has no axle, but is in friction gearing with the little pulleys, X X X. In this opaque disk there is a transparent one, W R B, composed of segments of white, red and blue glass, as shown in the engraving. The transparent disk, moreover, is set in the other one loosely, so that its motion may be suddenly checked by means of an elastic pad, E P, while the large disk is in full revolution. By this means the center is shifted from one color to another. Now let us see the result. When the instrument is at rest, nothing appears upon the screen except a very unpromising disk, divided into three portions. But the moment it begins to revolve the colors blend in various ways, forming rings of ever-changing hues, which succeed each other like those of the most gorgeous pin wheels of pyrotechnics. Suppose the disk revolves with its center in the white, then the blending of colors in each zone can be studied from the circles of Fig. 11. Fig. 12 represents the effect when the center is

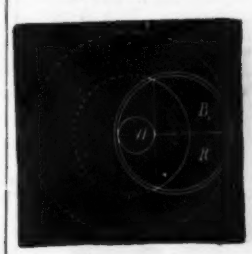


FIG. 11.

FIG. 12.

changed to blue, and Fig. 13 when it is shifted into the red. The dotted portions of the zones are those seen by *persistence* of vision. Now, by means of rapidly pressing the elastic pad against the projecting rim of the transparent disk, there is a constant shifting of centers, and the result is an infinite variety of splendid effects, Fig. 13.

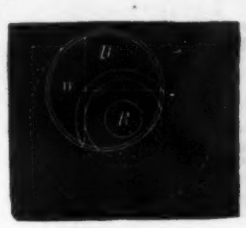


FIG. 13.

There is still another way of proving the theory of color. By throwing on the screen the intense light obtained by burning mercury, and by burning steel in the electric arc, the eye does not distinguish them; but by passing these lights through a prism, they are proved to contain very different elements. In fact, it would be all the same to the eye if only the three primary colors existed and no others, for the result would be the same. When combined, they would form white light.

Now, how do we know that the primary colors are red, green and violet, and not red, yellow and blue, as we were taught years ago, and as Sir David Brewster maintained? An experiment will answer this question. If red, yellow and blue are the primary colors, then green must be a mixture of yellow and blue. According to Young's theory, however, yellow and blue are equivalent to white, because by them we excite all the nerves, yellow being equal to red and green, and blue being equal to green and violet. If Brewster is right, blue and yellow light will make green; if Young is right, they will make white.

The lecturer then threw the two colors from two lanterns on the screen by means of colored glasses. The result was white. The same result was obtained with the chromatrope.

How does it come, then, that blue and yellow paints, mixed, produce green, as every child knows?

The color of paints is due to the light passing through them to the paper, and reflected from the paper under them. Now, white light, passing through blue paint, is robbed of every color except blue, green and violet; passing through yellow paint, it is robbed of all but yellow, red, orange and green. Green, therefore, is evidently the only color that both are agreed in trans-

mitting through them. The same effect is produced by taking the very glasses, blue and yellow, whose combination just produced white, and allowing the same white light to pass through both, instead of having separate sources of light. The result is green, because the combined glasses cut off every other color.

There is another property of the eye, with regard to the perception of color, which must not be overlooked. Like all other organs of the body, the eye is easily fatigued. If we look at red light for a long time, the nerves vibrating with it become so tired that they cease to act; if now the red is suddenly withdrawn and white substituted, the other two sets of nerves—namely, the green and violet—either act alone or are but faintly seconded by the red, and the consequence is, we do not see white at all, but a shade of green. This is strikingly shown by an experiment.

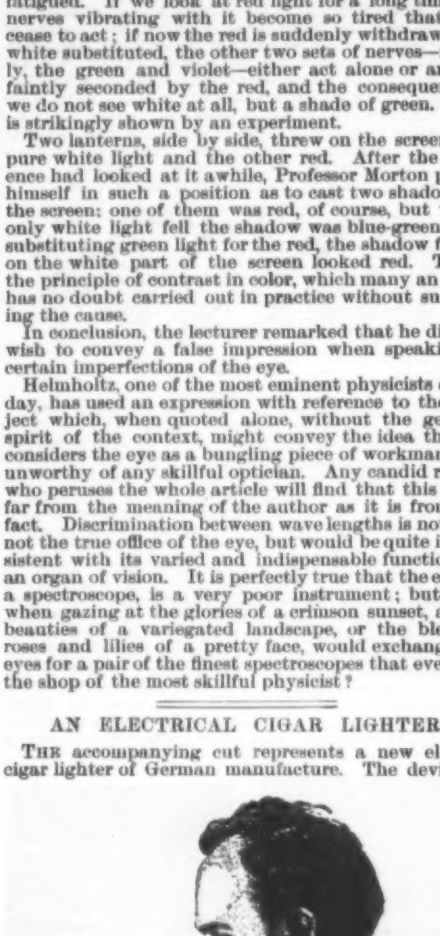
Two lanterns, side by side, threw on the screen, one pure white light and the other red. After the audience had looked at it awhile, Professor Morton placed himself in such a position as to cast two shadows on the screen; one of them was red, of course, but where only white light fell the shadow was blue-green. On substituting green light for the red, the shadow falling on the white part of the screen looked red. This is the principle of contrast in color, which many an artist has no doubt carried out in practice without suspecting the cause.

In conclusion, the lecturer remarked that he did not wish to convey a false impression when speaking of certain imperfections of the eye.

Helmholtz, one of the most eminent physicists of the day, has used an expression with reference to the subject which, when quoted alone, without the general spirit of the context, might convey the idea that he considers the eye as a bungling piece of workmanship, unworthy of any skillful optician. Any candid reader who peruses the whole article will find that this is as far from the meaning of the author as it is from the fact. Discrimination between wave lengths is not only not the true office of the eye, but would be quite inconsistent with its varied and indispensable functions as an organ of vision. It is perfectly true that the eye, as a spectroscope, is a very poor instrument; but who when gazing at the glories of a crimson sunset, at the beauties of a variegated landscape, or the blended roses and lilies of a pretty face, would exchange his eyes for a pair of the finest spectroscopes that ever left the shop of the most skillful physicist?

AN ELECTRICAL CIGAR LIGHTER.

THE accompanying cut represents a new electric cigar lighter of German manufacture. The device is



INCANDESCENT CIGAR LIGHTER.

introduced by R. Frister, of Berlin, and it is claimed that a number are actually in use. The apparatus is quite simple, and consists essentially of an incandescent lamp socket with a suitable handle connected by flexible lamp cord with wires carrying a 100 or 110 volt current. The outer end of the socket is supplied with a plug containing a spirally wound platinum wire, and this is brought to a state of incandescence when the circuit is closed by means of the push switch shown in the handle. This glow is sufficient to ignite a cigar when aided by a few vigorous puffs. Sufficient resistance is introduced in the handle of the lighter to suit the requirements of the current.—*Western Electrician.*

THE SIEMENS & HALSKE DYNAMOS.

THE tendency toward the employment of large units for the generation and distribution of electric light and power has been gradually growing in this country for some time. This has long been the practice in Europe and with very satisfactory results. Silvanus P. Thompson, in his recent work, "Dynamo-Electric Machinery," states that he has been of the opinion for years past that large dynamos are preferable, not because he has any admiration for mere bigness, but because, as in steam engines, the large machines may be made more efficient than the small in proportion to their cost. Gisbert Kapp has made the following estimate:

Diameter armature........	10 inches	15 inches
Revolutions per minute....	1,000	670
Number of glow lamps....	150	620
Price...	$500	$1,380
Electrical efficiency........	80 per cent.	89 per cent.

Showing four times the electrical output for a little more than twice the cost.

Siemens & Halske, recognizing the fact that large dynamos coupled directly to the steam engine shaft and running at comparatively low rates of speed, thereby saving the expense of belting, with its corresponding loss of power through friction, slipping, etc., were certain to be the machines of the future, turned their attention to the designing and construction of such machines, and have gone from 500 h. p. to 1,000 h. p., thence to 1,500 h. p., and now to 2,000 h. p., a size about three times as large as built so far in this country.

The accompanying illustration, Fig. 1, shows one of the 1,000 h. p. alternating machines coupled direct to a 1,000 h. p. Collman engine. This machine develops 700 kw., 2,000 volts and 350 amperes. The armature, which is 15·1 ft. in diameter, is stationary. It has 60 poles, and the field magnet ring consists of 60 bobbins, rotating inside the armature, which has the same number of coils. The outside diameter of the rotating field magnets is 12·2 ft. The number of revolutions is 100 per minute, so that there are 6,000 changes per minute in the poles.

The field magnets are excited by a direct current, which is brought from an exciter machine, every coil insulated with hard rubber from all metallic connections, and the stationary armature, such as is used in this type of machine, enables the maker to provide much better insulation than when the armature itself revolves.

The other illustration, Fig. 2, shows the direct current dynamo. It is of the inside pole ring type, which class has from four to twelve poles. They are placed in the form of a star inside the rotating armature. The

FIG. 1.—SIEMENS & HALSKE ALTERNATING CURRENT DIRECT COUPLED GENERATOR.

brushes, which are always of the same number as the field magnets, take off the current from the outside of the armature winding.

The armature itself consists of an iron core wound with copper segments. The special machine herewith illustrated has ten poles, and is designed for an output of 746,000 watts. This machine can be built without special commutator from 100 to 700 volts, and can be used for lighting and power. The loss of voltage in the armature is only 2 per cent. with maximum load. For exciting the field magnets, only 1½ per cent. is required. Therefore, the electrical efficiency of this machine is about 96½ per cent. It is shunt wound and has a surface velocity of 50 ft. per second.

The works of the Siemens & Halske Electric Company of America are located in Chicago. They receive all drawings from Berlin, and will duplicate the construction that has been the result of the vast experience gained by Siemens & Halske during the half century of their existence.—*Electrical World.*

ELECTRO-METALLURGY.*

THIS is not the first time a lecture has been delivered here on electro-metallurgy. I find that so long ago as January, 1841, there was a lecture on the subject by Mr. Brand.

At that time electro-metallurgy was very new and very small. It consisted solely of electro-plating and electrotyping. Electro-plating had begun to be practiced as a regular industry, but it was still a question whether the new kind of plating was good, and there were not a few silversmiths who would not offer electro-plate for sale because of its supposed inferiority to plate of the old style. That question has long been definitely settled by the fact that every week more than a ton of silver is deposited in the form of electro-plate.

Electrotype in 1841 was not so far advanced—it had not then been taken hold of by the artisan and manufacturer—it was still in the hands of the amateur.

While the voltaic battery was the cheapest source of electric current, electro-metallurgy was necessarily restricted to artistic metal work, or to those applications where the fine quality of the electrotype cast outweighed the consideration of its cost, or where only a thin film of metal was required for the protection of a baser metal from the action of the air.

Within this limited field, the electro-deposition of copper, of gold, of silver, of iron, and of nickel, has been carried on commercially with very great success and advantage for almost the whole period of the existence of the art. But beyond these bounds, set by the limitation of cost, it could not pass.

Now, all this is changed—since engineer and electrician have united their efforts to push to the utmost the practical effect of Faraday's great discovery, of the principle of generating electric currents by motive power. The outcome is the modern dynamo, with its result—cheap electricity. The same cause that has led to electric lighting, and to the electric transmission of power, has also led to a very great development of electro-metallurgic industry, and not only in the old directions, but in new. It is no longer a matter of depositing ounces or pounds of metal, but of tons and thousands of tons. And it is no longer with metal deposition merely that electro-metallurgy now deals, but also with the extraction of metals from their ores, and the fusion and welding of metals. Electro-metallurgy has in fact grown so large and many-branching that it is impossible to treat it in a complete manner in a single hour.

One of the latest developments is electric welding. This, in one of its forms, that invented by Elihu Thomson, has recently been so thoroughly explained and demonstrated by Sir Frederick Bramwell that it is not necessary for me to do more than mention it as belonging to the subject.

There is also another species of electric welding—that of Dr. Benardos—in which the electric arc is used after the manner of a blowpipe flame, to obtain the welding of such forms and thicknesses of iron, steel, and other metals, as would be difficult or impossible to weld in any other way; and not only is the electric blowpipe used for welding, but also for the repair of defects in steel and iron castings, by the fusion of pieces of metal, of the same kind as the casting, into the faulty place, so as to make it completely sound. This new kind of electric welding, as improved by Mr.

* Friday evening discourse delivered by Mr. J. Wilson Swan, at the Royal Institution, on May 20.—*Nature.*

Howard, is now of sufficient importance to entitle it to the full occupation of an evening. I therefore propose to leave it for detailed description to some other lecturer, and content myself with calling your attention to the interesting collection of specimens on the table, and in the library (lent by Messrs. Lloyd and Lloyd), showing the results of this process.

Even with this curtailment, the extent of the field is still too great, and I must reduce it further by omitting a considerable section of that portion which relates to the extraction of metals from their ores, and, in this connection, only speak of the extraction of aluminum.

But, in the first place, I am going to speak of the deposition of copper, and you will pardon me if I treat it as if you were unacquainted with the subject.

One of the wonderful things about the electro-deposition of copper, and in fact any other metal deposited from a solution of its salt in water, is, that bright, hard, solid metal, such as we are accustomed to see produced by means of fusion, can, by the action of the electric current, be made to separate from a liquid which has no appearance of metal about it.

The beginning of every electro-deposition process is the making a solution of the metal to be deposited. I am going to dissolve a piece of copper, the most elementary of all chemical operations, but I want to make it quite clear where the metal to be deposited comes from—to show that it is actually in the solution, and actually comes out of it again; for that is an effect so surprising that it requires both imagination and demonstration to make it evident. There is projected on the screen a glass cell containing nitric acid. Mr. Lennox will put into it a piece of copper. He has done so; it quickly disappears, and a blue solution of copper nitrate is formed. Now, if I pass an electric current through this solution, or through some solution of the same kind, which, to save time, has been prepared beforehand, and immerse in it, a little apart from each other—the positive and negative wires coming from some generator of electric current—this will happen: metallic copper will come out of the solution, and attach itself as a coating to the negative wire, and consequently that wire will grow in thickness. At the other wire—the positive—exactly the reverse action will take place. There, if the positive wire be copper, it will gradually dissolve, and become thinner. The quantity of metal deposited on the negative wire will almost exactly equal the quantity dissolved from the positive, and therefore the solution will contain the same quantity of metal at the end of the experiment as at first, but it will not be the same metal; it will be fresh metal dissolved from the positive wire, and the metal originally contained in the solution will have been deposited as metallic copper.

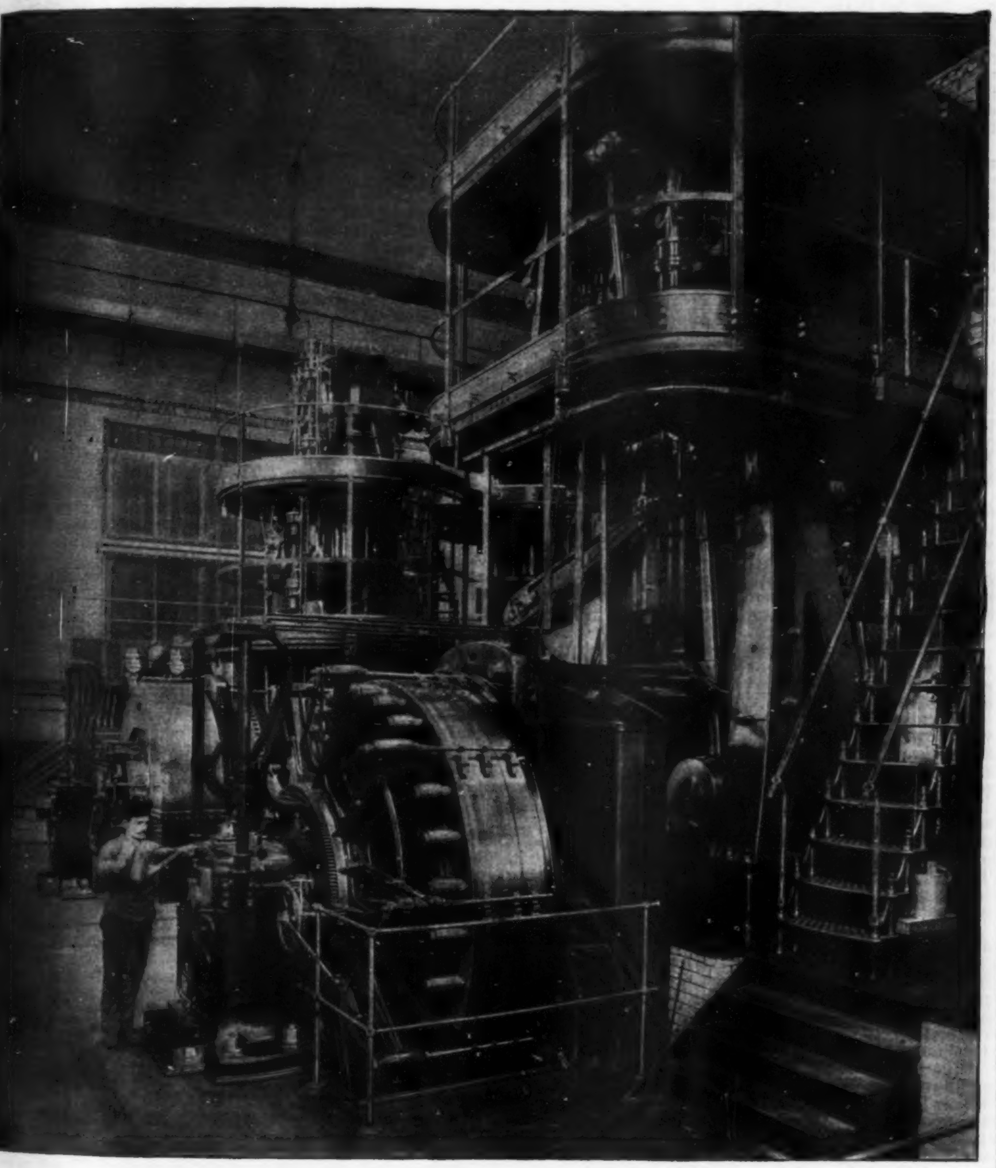


FIG. 2.—SIEMENS & HALSKE CONTINUOUS CURRENT DIRECT COUPLED GENERATOR.

I will show on the screen this process in operation. Here are the two wires I spoke of. The electric circuit, which includes these two wires, is so arranged that on its completion the thick wire will be the positive and the thin wire the negative. Now please complete the circuit. One wire (the positive) is carrying an electric current into the copper solution and the other (the negative) is carrying the current away. The solution is conveying the current between the wires, and one of the incidents of the transport of current from wire to wire by the solution is electro-chemical decomposition, or electrolysis; and the result of that is, the deposition, out of the solution, of copper, upon one wire, and the dissolving away, or entering into solution, of copper, from the other. Now it can be clearly seen that the wire that was thick is now thin, and the wire that was thin is now thick.

Imagine the growing wire to be an electrotype mould, and that the deposit of copper which formed on the wire has spread over the surface and formed a nearly uniform film, and that by continuing the process it has become thick—that deposit, stripped from the mould, would be an electrotype.

Or imagine the negative wire to be a thin sheet of pure copper and the positive wire to be a thick sheet of impure copper, and suppose the action carried on so far that the thin sheet has become thick by the deposition of copper upon it from the solution, and the thick one thin by its copper entering into solution, that case would represent the condition of things in electrolytic copper refining.

Allow your imagination to take one more short flight, and suppose that this is not a solution of copper, but one of silver, and that the growing wire is a teapot to be silvered; and, further, suppose that the dissolving electrode is silver, and you will then understand the principle of electro-plating.

It requires very little explanation to make the ordinary arrangement of electrotyping intelligible. Here is a trough containing sulphate of copper solution. Here is a mould that, through the kindness of Messrs. Elkington, has been prepared for me; this is connected with the negative pole of a battery—and here is a plate of copper connected with the positive pole. When I immerse the mould in the solution—at about two inches from the copper plate—the electrical circuit is completed, and the same electrolytic action that the experiment illustrated will take place. Copper will be deposited on the mould, and will be dissolved in equal quantity from the copper plate, and the supply of copper in the solution will thus be kept up. As it will take a little time to obtain the result I wish to show, I will put this aside for ten minutes or so, and proceed to speak of different applications of this principle of copper deposition.

For the reproduction of fine works of art in metal, electrotype is unapproachable. The extreme minuteness with which every touch of graver or modeling tool is copied by the deposited metal film separates electrotype by a wide space from all other modes of casting. Even the daguerreotype image is not too exquisitely fine for electrotype to copy it so perfectly that the picture is almost as vivid in the cast as in the original.

It is this quality that has given to electrotype a *role* which no other process can fill, and, so far, its practical utility is not greatly dependent on the cost of the current. This applies to all those most beautiful things here and in the library, lent by Messrs. Elkington. These could all have been produced commercially, even if there had been nothing better for the generation of the current than Smee's battery—a very good battery, by the way, for small operations in copper deposition. It gives a very low electro-motive force and that is a defect, but in copper deposition the half volt or so is generally sufficient to produce, automatically, the required current density.

One of the uses of electrotype, not greatly affected by the cost of deposition, is that of the multiplication of printing surfaces. In these days of illustrated periodicals, electrotype has come more and more into use for making duplicate blocks from wood engravings, which would soon be worn out and useless if printed from direct. It is also employed to make casts from set-up type, to be used instead of ordinary stereotype casts, when long numbers of a book have to be printed; also as a means of copying engraved copper plates. Here are examples of all these uses of the electrotype process. The electro-blocks are lent by Messrs. Richardson & Co., and the copper plates by the Director-General of the Ordnance Survey Office, Southampton.

The plates illustrate the method employed at Southampton in the map printing department. The original plates are not printed from except to take proofs. The published maps are all printed from electrotypes. Here is an original plate—here the matrix, or first electro, with, of course, all the lines raised which are sunk in the original. The second electro is, like the original, an intaglio. Here is a print from it, and here one from the original plate. Practically they are indistinguishable from each other, and bear eloquent testimony to the wonderful power of electrotype to transmit an exceedingly faithful copy of such a surface.

Nickel has, of late years, come into extensive use for what is termed nickel plating, as applied to coating polished steel and brass with nickel. Nickel not only has the advantage over silver of cheapness, but also, in some circumstances, of greater resistance to the action of the air.

Another metal, usually deposited in the form of a coating, is iron. The electrolytic deposit of iron is peculiarly hard—so much so, that it is commonly but erroneously spoken of as *steel* facing. The deposition of a film of iron upon engraved copper plates, as a means of preventing the wear incidental to their use in being printed from, has become almost universal. Valuable etchings, mezzotints and photogravure plates are thus made to bear a thousand or more impressions without injury. By dissolving off the iron veil with weak acid, when the first signs of wear appear on the surface of the plate, and recoating it with iron, an engraved copper plate is, for all practical purposes, everlasting.

In this case, of course, the film of iron is extremely thin—one or two hundred-thousandths of an inch. But it is possible to produce most of the metals commonly used as coatings in a more massive form. Here, for example, is an iron rod half an inch in diameter, entirely formed by electrolytic deposition. I am indebted to Mr. Roberts-Austen for being able to show this, and also for this other example of a solid deposit of iron, and for this beautiful specimen of electrolytic coating with iron. Here also are solid deposits of silver. This drinking cup is a solid silver electro-deposit.

These are all departments of electro-metallurgy which would have maintained a perfectly healthy industrial existence and growth without the dynamo; but now I come to speak of a branch of the subject—electrolytic copper refining—which, without that source of cheap electricity, could not have existed. This is the most extensive of all the applications of electro-chemistry, and is rendering valuable assistance to electrical engineering by the improvement it has led to in the conductivity of copper wire.

One of the results of this is seen in the raising of the commercial standard of electrical conductivity.

Ten years ago, contracts for copper wire for telegraphy stipulated for a minimum conductivity of 95 per cent. of Matthiessen's standard of pure copper. Now, chiefly owing to electrolytic refining, a conductivity of 100 per cent. is demanded by the buyer and conceded by the manufacturer.

To show the difference between the past and present state of things in relation to the commercial conductivity of copper, I am going to exhibit on the screen measurements of the resistance of six pieces of wire of equal length and equal cross section—they have been drawn through the same drawplate. Three of the pieces are new, and three are old. The three new pieces are made from electrolytic copper, and are representative of the present state of things. The three old pieces are taken from three well known old submarine telegraph cables, and they show how very bad the copper was when it was first employed for telegraphic purposes, and how great has been the improvement. I will take No. 1 wire as the standard of comparison. It is a piece of the wire about to be supplied to the Post Office Telegraph Department for trunk telephone lines. It will show the very high standard of conductivity that has been reached in the copper of commerce. I am indebted for it, and for two out of three of the old cable wires, to Mr. Preece. No. 2 wire is made from electrolytic copper, deposited in my own laboratory. No. 3 is also electrolytic copper, but such as is commercially produced in electrolytic copper refining; it has been supplied to me by Mr. Bolton, to whom I am also indebted for wire No. 6—a particularly interesting specimen: it is from the first transatlantic cable—the cable of 1858. No. 4 wire is from the Ostend cable of 1860, and No. 5 wire is from the old Dutch cable. These wires are so arranged that I can send a small and constant current partly through any one of them and partly through a galva-

nometer. When this is done the result will be a deflection of the spot of light on the scale from the zero point to an extent corresponding to the resistance of the particular wire in the circuit. The worse the wire is, the greater will be the deflection. We will begin with the Post Office sample first. I connect the galvanometer terminals to wire No. 1; you see there is a deflection of ten degrees. I will now shift the contacts to wire No. 2—exactly the same length of wire is included—but now you see there is a deflection of slightly less than ten degrees, showing that this wire has a little lower resistance than No. 1. The difference is very small—it may be 2 per cent.—and 2 per cent. less of it would be required to conduct as well as the No. 1 wire. The next is No. 3. This is Mr. Bolton's wire, and shows a resistance almost equal to the last.

Nos. 1, 2 and 3 are, therefore, nearly alike, and have a degree of conductivity almost as high as it can possibly be.

Now we come to the three old wires.

We will take No. 4 (the Ostend cable). There, you see, is a great difference. Instead of the spot of light being on the tenth degree, it is upon the eleventh.

We will now try No. 5 (the Dutch cable). That drives the index to 17.

Now I change to No. 6 (the old Atlantic cable), and we have a deflection of no less than 25 degrees. I suppose we may assume that this wire fairly represents the commercial conductivity of copper in 1858, for it is highly probable that for a work so important as the first Atlantic cable every care would be taken in the selection of the copper.

The result of this experiment shows that the copper of that cable was extremely bad as a conductor—that, in fact, it is 150 per cent. worse than the best commercial copper of to-day. In other words, it shows that, in point of electrical conductivity, one ton of the copper of to-day will go as far as two and a half tons of such copper as was used for the cable of 1858.

This change is largely due to electrolytic copper refining.

The process of electrolytic copper refining is the same in principle as that which produced the thickening of one of the wires and the thinning of the other in my first experiment. To prepare the crude copper for the refining process it is cast into slabs; these form the anodes, and correspond to the wire which in my first experiment became thin. The cathodes, corresponding to the wire which became thick, are formed of thin plates of pure copper. Here are plates such as are used in electrolytic copper refining works. They are portions of actual cathodes and anodes, and represent the state of things at the commencement, and at the end, of the depositing operation—an operation that takes several weeks to complete, and effect the great change these plates show. In copper refining works an immense number of these plates, each having 6 to 10 square feet of superficial area, are operated upon together in a great number of large wooden vats containing sulphate of copper solution and a small proportion of sulphuric acid. Electric current from a dynamo, driven by a steam engine or water power, is conveyed by massive copper conductors to the vats, arranged in long lines of 50 or 100 or more in series. Thick copper bars connect adjoining vats, and provide a positive and negative support for the plates, which hang in the solution opposite each other, two or three inches apart. During the process the impure slabs dissolve, and at the same time pure copper is deposited from the solution upon the thin plates. The deposition and dissolving go on slowly, in some cases very slowly, for a slow action takes less power, and gives purer copper than a more rapid one. The usual rate is one to ten amperes per square foot of cathode surface. You will better realize what these rates of deposit mean, when I say that one ampere per square foot rate of deposition gives for each foot of cathode surface nearly one ounce of copper in twenty-four hours, and a thickness of one eight-hundredth of an inch; and, therefore, the production of one ton of copper at that rate in twenty-four hours would require a cathode surface in the vats, in round numbers, of 36,000 square feet. At the higher rate of ten amperes per square foot, which is used where coal is cheap, one-tenth of this area would be required.

The importance of the electrolytic copper refining industry, and the extent of the plant connected with it, may be inferred from the fact that, reckoning the united production of all the electrolytic copper works in the world, nearly one ton of copper is deposited every quarter of an hour.

Very little power is required for copper deposition if the extent of the dissolving and depositing surfaces is large, relatively to the quantity of copper deposited in a given time.

Some of the impurities ordinarily found in crude copper are valuable. Silver and gold are common impurities, and these and some other impurities do not enter into solution, but fall down as black mud, are recovered, and go to diminish the cost of the process or increase the profit; and even those impurities which enter into solution are, under ordinary conditions, almost completely separated.

Electrolytic copper refining is both an economical and an effective process. The deposited copper is exceptionally pure. At one time it was supposed that it must necessarily be quite pure, but this is not the case; other metals can be deposited with the copper, but it is not difficult to realize in practice a close approximation to absolute purity in the deposited copper. Here is an example of the deposition of a mixed metal, brass, that is, copper and zinc deposited together, and there are in the library a number of interesting specimens of mixed metal deposition. These deposits of brass and other alloys show that more than one metal can be deposited at the same time. The great enemy to conductivity in copper is arsenic, and the deposition of arsenic as well as copper is one of the things to be guarded against in electrolytic copper refining. Not only are the chemical characteristics of electrolytically refined copper generally good, but its mechanical properties are largely controllable. Usually electrolytic copper is melted down and cast into billets of the form required for rolling and wire drawing. This treatment not only involves cost, but the copper is apt to imbibe impurity during fusion; though, if the process is carefully conducted, the deterioration is slight.

But it is evident that the remelting of the deposited copper is a thing to be avoided if possible, and the question naturally arises, why, now that deposition costs so little, may not the beautiful principle which comes into play in electrotype, and which enables the most complicated forms to be faithfully copied, be taken advantage of to give to plainer and heavier objects their ultimate form?

There are several reasons why this idea is not more frequently acted upon. One is that the process of electrolytic deposition is slow; another, that knowledge of the conditions necessary for obtaining a deposit having the required strength and other qualities is not very widespread. Moreover, in the electrolytic deposition of copper, and indeed of all metals, there is a strong tendency to roughness on the outside of the deposit, and to excrescent growths, the removal of which involve waste of labor and material. These tendencies can to a very great extent be counteracted by careful manipulation and the use of suitable solutions, and they can also be counteracted by mechanical means. This has been done by Mr. Elmore. He remedies the faults I have mentioned by causing a burnisher of agate (arranged after the manner of a tool in a screw-cutting lathe) to press upon and traverse a revolving cylindrical surface on which the deposit is taking place, and while it is immersed in the copper solution. The result is that it is kept smooth and bright to the end of the process.

But the use of a burnisher is not the only means available for the production of a smooth deposit. It was observed in the early days of electro-plating how great a change was effected in the character of the metal deposited by the presence of a very small quantity of certain impurities. It was found, for example, that an exceedingly minute dose of bisulphide of carbon, if put into a bath from which the silver was being deposited, caused the deposit to change from dull to bright.

I have lately had experience of a similar kind with nickel and with copper. I was working with a hot solution of nickel, and up to a certain point the deposit had the usual dead-gray appearance. Suddenly, and without doing anything more than putting in a new cathode, I found the character of the deposit completely changed. Instead of the gray, tough, adherent deposit, there was produced a brittle, specular deposit, which scaled off in brilliantly shining flakes of metal. I sought for the cause of this extraordinary change, and traced it to the accidental introduction into the solution of a minute quantity of glue.

By adding gelatine to a fresh nickel solution I obtained the same peculiar bright and brittle deposit that had resulted from the accident. I then made a similar addition to a solution of copper, and when I hit the right quantity—an exceedingly minute one—bright copper, instead of dull or crystalline, was deposited. Here are some specimens. These were deposited on a bright surface, and they are bright on both sides.

Not only is the copper made bright, under the conditions I have described, but, if the proportion of the gelatine be carried to the utmost that is consistent with the production of a bright deposit, it becomes exceedingly hard and brittle. Beyond this point the deposit is partly bright and partly dead, the arrangement of the patches of dead and bright being in some cases very peculiar, and suggestive of a strong conflict of opposing forces.

Before I leave the subject of copper deposition, I may mention that I have found the range of current density within which it is possible to obtain a deposit of reguline metal far wider than is commonly supposed.

The rate of deposition in copper refining is usually very slow, and it is one of the drawbacks of the process, since slow deposition necessitates large plant. But rapid deposition necessitates a larger consumption of power, and larger cost on that account, and, therefore, there is a point beyond which it is not good economy to go, in the direction of more rapid deposition. Still there are cases where, if we had the power to deposit more rapidly, it might be found useful to exercise it. The subject of more rapid deposition is also interesting from a scientific point of view. I therefore mention an unusual result I have arrived at in this direction.

Taking as one extreme the slow rate of deposit of one ampere per square foot of cathode—a rate not infrequent in copper refining—I have found that the limit in the other direction is not reached by a rate of deposit one thousand times faster. I have produced, and I hope to be able to produce before you, a perfectly good deposit of copper, with a current density of 1,000 amperes per square foot of cathode.

This cell contains a solution of copper nitrate with a small proportion of ammonium chloride. The plate on which I am going to produce a deposit of copper has an exposed surface of 21 square inches. Opposite, at a distance of one inch, is a plate of copper. When I close the circuit a current of 140 amperes is passing through the solution. I continue this for just one minute. Now I wash it and remove the outer edge so as to detach the deposit, and as you see, I have a sheet of good copper—an electrotype.

To have produced a deposit of this thickness at the ordinary rate used in electrotyping operations would have occupied more than an hour.

In this experiment an extreme degree of rapidity of deposition has been shown. I do not intend to suggest such a rate of practical value. But it is at least interesting, as showing that the characteristic properties of copper are not less perfectly developed when the atoms of metal have been piled up one on the other at this extremely rapid rate than when there is slower aggregation.

I think it probable that a rate of deposit intermediate between this rate and the usual one of about 10 amperes per square foot may frequently be useful, for no doubt the slowness of the rate of deposit has often prevented electrotype from being made use of where, if the rate could have been increased ten times, it might have been used with advantage.

Here are some thick plates, deposited at the rate of 100 amperes per square foot. They are as solid and as free from flaw as plates deposited ten times more slowly.

I said that electrolytic copper refining owed its existence to the discovery and improvement of the dynamo, and that other electro-metallurgic industries had originated from the same cause. One of these industries is the electrolytic production of aluminum.

When Deville produced aluminum by the action of sodium on aluminum chloride, exaggerated expectations were entertained of the great part it was about to play in metallurgy. It was very soon found that aluminum had not all the virtues that its too sanguine friends had claimed for it, but that it had a great many most valuable properties, and, given a certain degree of cheapness, a number of useful applications could be found for it.

Some of these are suggested and shown by the various articles made of aluminum, kindly lent by the Metal Reduction Syndicate, and metallurgical research is rapidly extending our knowledge of its importance in connection with the improvement of steel castings, and the production of bronzes and other alloys of extraordinary strength. The cost of aluminum produced by Deville's process was too great to permit of its use on any large scale for these purposes.

After Davy demonstrated, by the electrolytic extraction of potassium and sodium, the power of the electric current to break down the strong combination existing between the alkaline metals and oxygen, it seemed natural to expect that aluminum would also be reduced by the same means. But Davy did not succeed in producing any appreciable quantity of aluminum by the electrolytic method.

Deville and Bunsen were more successful, but they did not possess the modern dynamo; that has made all the difference between the small experimental results they achieved and the industrial production of to-day, a production now so large that I suppose every day it amounts to at least one ton, and has resulted in a very great reduction of the price of the metal.

There are two electrolytic processes at work. One is the Hall process—employed at Pittsburg and at Patricroft, Manchester—and now in experimental operation here. The other, the Herault process, worked at Neuhausen, is not greatly different from the Hall process—the shape of the furnace or crucible is different, and the composition of the bath yielding the aluminum may be different, but in all essentials these two processes are one and the same. They depend on the electrolysis of a fused bath, composed of cryolite, aluminum fluoride, fluorspar, and alumina.

In the Hall process this mixture is contained in a carbon-lined iron crucible—the cathode in an electric circuit; and between which and the anode—a stick of carbon immersed in the fused bath—a difference of potential of 10 volts is maintained. In carrying out the process on a manufacturing scale, there are many of these sticks of carbon to each bath. Here, in our experimental furnace, there is only one.

The heat developed by the passing of so large a current as we are using (180 amperes) through an electrolyte of but a few inches area in cross section is sufficient to melt and keep red hot the fluorides in which the alumina is dissolved.

The electrolytic action results in the separation of aluminum from oxygen. The metal settles to the bottom of the pot, and is tapped or ladled out from time to time as it accumulates. The oxygen goes to the carbon cylinder, and burns it away at about the same rate as that at which aluminum is produced. It is only necessary to keep up the supply of alumina to enable the operation to be continued for a long time. I mean, of course, in addition to the keeping up of the current and the supply of carbon at the anode.

By far the greater part of the cost of aluminum obtained by electrolysis is the cost of motive power: 20 horse power hours are expended to produce 1 pound of aluminum. Therefore it is essential for the cheap production of aluminum to have cheap motive power.

There is one feature about the Neuhausen production of aluminum which is very striking, and that is the generation of the electric current by means of water power derived from a portion of the falls of the Rhine at Schaffhausen.

The motive for making use of water power is economy. But, apart from that, it is interesting to see water replacing coal, not only in the production of power, but also in the production of the heat required in a smelting furnace.

Here is the Hall apparatus on a small scale. It is simply a carbon-lined iron crucible, and a thick stick of carbon. As already mentioned, the crucible is the cathode, the stick of carbon the anode.

As the process takes time to get into full operation, it was commenced some hours ago, and at the rate at which it has been working we should by now have produced several ounces of aluminum. In beginning the process the charge has first to be melted. This is done by bringing the carbon stick into contact with the bottom of the crucible, so as to allow the current to pass from carbon to carbon to develop heat between the electrodes.

The alumina compound, which, when melted, forms the bath, is added, in powder, little by little, and, when sufficient is melted, the carbon stick is raised out of contact with the bottom, and the electrolytic action then commences.

I will now ask Mr. Sample to empty the crucible and let us see the result of the operation, and while he is doing so I take the opportunity of expressing my very sincere thanks for his having so kindly and so successfully carried out this most interesting demonstration of the latest and one of the most important of all the applications of electricity to metallurgical operations.

Here is the result of our experiment. It is not very large certainly, but it is quite enough for our purpose, which is to illustrate the principle of a newly developed electro-metallurgical industry directly derived from discoveries made at the Royal Institution.

TERNARY ALLOYS.

By Mr. C. R. Alder Wright.

In this paper are described the results of experiments made with ternary mixtures of molten metals containing aluminum as the lighter "immiscible" metal, lead (or bismuth) as the heavier one, and tin (or silver) as the "solvent" metal, the observations being made in precisely the same way as those previously described. Incidentally it is mentioned that the aluminum now obtainable commercially in quantity is considerably purer than that supplied at some eight times the price upward of four years ago, when the experiments were first commenced; in 1887-88 so-called 99 per cent. aluminum invariably contained much more than 1 per cent. of matter not aluminum (at least so far as

numerous samples obtained by the author from different makers for the purpose of the investigation were concerned); silicon and iron are still the chief impurities, the former existing in conditions closely analogous to those observed in the case of carbon in cast iron, etc., *i. e.*, partly dissolved in the aluminum (when fused) apparently in the amorphous form, and partly undissolved in the graphitoidal form. On solution in diluted aqua-regia the former variety of silicon becomes oxidized and more or less completely dissolved in the acid fluid, while the latter is mostly unattacked and undissolved; much as the dissolved amorphous carbon in cast iron, etc., is volatilized in combination with hydrogen in solution in hydrochloric acid, while the undissolved admixed graphitoidal carbon remains unaffected by the acid.

The "critical curves" obtained at the temperature of about 800° C. with the ternary mixtures aluminum-lead-tin and aluminum-bismuth-tin and at near 870° C. with the mixtures aluminum-lead-silver and aluminum-bismuth-silver are described and graphically represented; on comparison with the four corresponding curves where zinc replaces aluminum, it is noticeable that in every case the curve obtained with aluminum as light immiscible metal is situated outside the corresponding curve where zinc was used, notwithstanding that a somewhat higher temperature was employed; while the curve obtained with bismuth as heavier immiscible metal invariably lies inside the corresponding curve where lead is used, the temperature conditions being the same. The examination of the general contours of the curves and the directions of slope, etc., of the tie lines lead to the conclusion that whereas zinc and silver form definite compounds, $AgZn_5$ and Ag_4Zn_5, the formation of which produces peculiar bulges (inward and outward) at certain portions of the critical curves when these two metals are present, no such results are traceable in the case of aluminum and silver. On the other hand, the configurations of the tie lines with zinc-lead-tin and aluminum-lead-tin alloys are alike, but different from those observed in all other cases, leading to the inference that the cause is the tendency toward the formation of certain definite compounds, Pb_2Sn on the one hand and Zn_2Sn and Al_2Sn on the other.

The positions of the "limiting points," or vanishing points of the systems of tie lines deduced in the four cases are such as to show that while the proportions in which the two immiscible metals are present at the limiting point is always pretty close to that indicating some definite atomic ratio, yet this ratio differs widely with the nature of the "solvent" metal; thus with the four combinations the atomic ratios were approximately those indicated by the formulas: Aluminum-lead-tin, Al_3Pb_2; aluminum-lead-silver, $AlPb_3$; aluminum-bismuth-tin, $Al_{10}Bi$; aluminum-bismuth-silver, $AlBi_3$.

All four aluminum-containing alloys are freely oxidizable when molten; even when the atmosphere surrounding the crucible is rendered reducing as far as possible, and access of air prevented as much as practicable by directing a jet of coal gas into the crucible, a notable amount of oxidation takes place during the admixture of the metals by vigorous stirring; the effect of this is that the mixtures flour considerably, so that a large portion of the metals originally used is lost, being pulverized and left behind with the scoriæ in the mixing crucible, when the fluid mixture is poured off into long, narrow, clay test tubes, in which the mass is kept molten for some eight hours.—*Proc. Roy. Soc.*, 1892.

OBSERVATIONS ON THE HABITS OF A MASON WASP.

A SMALL wasp (*Odynerus murareus*) hovered humming softly over a half-curled leaf of a rose bush. The wings vibrated so quickly they seemed to involve the insect in a hazy vapor. Small caterpillars were feeding on the leaves of the bush, and some of the leaves were coiled by the caterpillars into a tubular dwelling with a web, preparatory to the caterpillars' assuming the pupa state. One of the fine threads glistened in the sunbeam, and following the wave of light its motion gave, as it swayed backward and forward to the ground, I noticed a small green caterpillar half suspended, half touching the earth. The length of its silken rope exhausted for a time the secretion that made it, and prevented it reaching the earth, where the caterpillar intended protecting itself in some tiny fissure or crevice until it could feel the danger that menaced it in its leafy dwelling on the rosebush had gone, and then to climb back there in safety.

But the wasp had followed the caterpillar from the curled leaf, apparently conscious that the thread was limited, then darting, clung to the caterpillar, swinging there. The additional weight of the wasp broke the thread, and the wasp and caterpillar went to the ground. The abdomen of the wasp curved on to the caterpillar writhing in its secure grasp. This action of the abdomen was evidently to sting the caterpillar, for the latter soon lost all power and became relaxed. The jaws of the wasp held it firm, and the antennæ hung over it. The little wasp then poised itself on its wings, as if to ascertain the weight or balancing of its helpless load, before flying away with it. It then rose, humming its way to the drapery folds on a statue of Flora, where it had constructed its first cell. It is curious that this same statue, and almost the same part of it, has for several years been selected by one of these wasps to build its nest on. It is not reasonable to suppose it to be the same insect that returns year after year to the same spot. It implies that the place is selected so often because of its adaptability to the requirements of this species of mason wasp. May not this apply also to many migratory birds, as the swallow tribe, that are said to return to the same spot to build and rear their young? Not because the same spot is utilized by the same species year after year, is it necessarily the same individuals that return to it, but that it happens to be selected by others of the same species because of the special advantages existing there, inducing the birds to select it so repeatedly.

The wasp, after alighting upon the edge of its cell, looked in, and as if its position was not convenient for depositing the caterpillar, the industrious creature moved a little further round its cell, then going in once more, coiled the caterpillar among the others round the single egg there. This caterpillar was the last to be deposited in that cell, and the wasp, apparently satisfied with the work, and knowing it had stored the requisite amount of food for the voracious grub about to turn from the egg, rested a little time on the edge of the cell, pluming its antennæ with its forelegs and feet, and moving its head from time to time from side to side on its pivot-like neck, as though viewing and considering the surroundings. When it was ready it soared away, quite indifferent to the bees at clover flowers on the lawn and the starlings whistling in the ash trees. All these were nothing to the little wasp so intent on its own labors in the warm, bright sunshine, and so satisfied with the selection of the spot and the security provided for its immature young. To a small body of water at some little distance it betakes itself, and after imbibing some with a

FIG. 1.—*Odynerus murareus*. (Natural size.)

drawing in and extension of the abdomen, as though it required effort, it seeks some fine dry earth on the border among the flowers, which it moistens with the fluid it has imbibed, and with its strong jaws works into a kind of cement of the same quality as the cell is made of. It makes incessant journeys now to the water, and then to the earth, and back again to its cell, which it gradually closes over, sealing the caterpillars and egg quite close. By degrees this cover is moulded into a hollow, forming the base of a succeeding cell, and the sides are slowly raised by many small particles until another cell is constructed, ready for an egg and caterpillars for the wasp's young, in continuation of the one last completed. The wasp always finished a cell about midday, and was not to be seen again until evening, when it returned and utilized the cell for a demesne during the night, resting with its head upward. The next morning another egg is laid, and more caterpillars (the number varying from six to nine) are brought and deposited as in the first cell. The caterpillars are always stung sufficiently not to kill, but to send into a state of coma, when they

FIG. 2.—Clay nest of *Odynerus murareus* in the hollow formed by the drapery folds of a statue (magnified).

lose all power of voluntary motion, without pain or sense to feel injury.

Nature in the instance of this wasp seems to exercise a kindlier means of utilizing one life for the food of another than she does in many instances, as in the case of the butcher bird impaling insects on the thorns in the wayside hedge, where they slowly die a painful death. After constructing nine to ten cells, the wasp leaves forever the young it will never know, in the habitation that has cost it so much labor. The July sun, and the summer rain, pour on to this clay home of the wasp, and at night the dew, with a silent footfall, covers it with beads of moisture, yet the growing life within this simple habitation receives no injury from the alternate heat and wet.

In about fourteen days the egg turns into the larva, that at once commences to devour the comatose caterpillars. By the time these are eaten the grub has become matured, and it passes excrement for the first time, then spinning a close web round itself, inside the cell, with the excrement left between the web and the

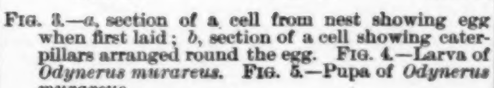


FIG. 3. FIG. 4. FIG. 5.

FIG. 3.—*a*, section of a cell from nest showing egg when first laid; *b*, section of a cell showing caterpillars arranged round the egg. FIG. 4.—Larva of *Odynerus murareus*. FIG. 5.—Pupa of *Odynerus murareus*.

cell wall, so that the former does not come in contact to corrupt the living larva of the wasp. The latter now gradually changes to the pupa state, the body moulding into three divisions, the wings and the other appendages becoming apparent, and growth goes on until the matured insect works its way from darkness through its earthen casement into the bright light of day. The mind of the insect perfected, ready for immediate action, at once performs the functions of which its development is capable, the judgment of distance, of form, color, and scent. These and other exciting agents act on the creature's mind formed for instant function, and it wings its way from the place of its birth through sunbeam and shadow, a pleased and a perfect life.—*Henry W. King, in Hardwicke's Science-Gossip.*

THE WILD BOAR AND HIS WAYS.

By DR. G. ARCHIE STOCKWELL, F.Z.S.

FORTUNATELY, or unfortunately, as the case may be, America has no representatives of *Sus scrofa*, the wild boar proper, save as improved upon by civilization and breeding, for the feral swine of Brazil, Venezuela, Honduras, Mexico, Canada, Florida, and the Mississippi bottoms are only reversions of the domestic form. The peccaries, too, though belonging to the same zoological family, are nevertheless a specifically distinct race, the relationship being no nearer than between the dog and wolf, or the cat and tiger.

In various parts of the "old world," however, true wild swine still roam, though every year sees their range more contracted, and their numbers decreased, so that now it is only a matter of a few decades when the race will be extinct in Europe. Already the Campagna and Pontine marshes of Italy, that a quarter of a century agone were the resort of the pig-sticking fraternity in general, and English sportsmen in particular, are entirely forsaken by boars, and the creatures themselves forgotten, or remembered only as ferocious representatives of the past. Considerable numbers, however, still haunt the marshes of the Turco-Grecian peninsula and of central and southern Russia; the dim, endless forests of Germany and Lithuania shelter many formidable representatives in point of courage and size, since here they have hardly learned how dangerous man may become as a foe; and a few still roam at large in Andalusia, Savoy, Normandy, Denmark, and the Low Countries, where, penetrating the outlying villages and hamlets, they are the terror of the simple peasantry.

Though the human race is undoubtedly the gainer by the fact that the boar has had a ring put through his nose, and his great strength, by processes of evolution and breeding, transformed into fat, many there are, honest sportsmen, who view the change with regret. Since boar hunting in the main is unattainable save in remote districts difficult of access, they are inclined to view it as the *ne plus ultra* of field sports; they do not forget it was ever deemed a princely and noble diversion; that in England, from the time of the heptarchy down to the Saxon restoration, it was a prerogative obtainable only through royal sanction or favor. Indeed, during the reign of William Rufus, to take the life of a fellow being was less criminal than to unauthorizedly slay a wild hog, since the former *might* be condoned by fine, while the *least* penalty attaching to the latter was loss of the right hand if a noble, of the head if a peasant or serf. Under King Hoeldda, of Wales, the nobility alone could participate in the hunt, and then only in the presence, or under special sanction, of royalty, save during the latter half of November and the first fortnight in December, when wild pigs are apt to prove not only numerous but aggressive. Xenophon tells us he bred his sons to the sport as a school of courage and self-reliance, inculcating a knowledge of arms and taste for war; and the *bass-reliefs* and sculptures of the extinct civilizations of Assyria and Egypt depict their monarchs in the chase, pursuing the wild boar in chariots, on horseback, even engaging him single handed on foot.

The hunting pieces of Teniers, Snyders, and Despartes afford excellent evidence of the sport as it obtained in Europe during the sixteenth, seventeenth, and eighteenth centuries, and we gather therefrom it was no less exciting and dangerous than in our own day. These paintings also depict in most faithful way the character of the dogs employed—strong-limbed, deep-chested, compact-built creatures with heavy jowls, apparently a cross between the bloodhound and mastiff, and that in a measure survive in the so-called Danish hound, or "Great Dane" of modern bench shows. There was also, in the middle ages, a famous breed known as Pomeranian boar hounds, more or less heterogeneous in character, but markedly of wolfish strain, and held in such repute "a leash (couple and a half) was the choicest gift that could be tendered a sovereign."

In both history and song Britain is celebrated as the whilom home of the boar, though the last of the race disappeared long before the hart and roebuck went out from the list of English game. His soused head, garnished with sprigs of holly and other evergreens appears inseparable from the old time yule-tide feast, and other evidences of his occupancy still linger in the so-called "forest pigs" of Hampshire, whose high crests, long manes and gaunt bodies are the result of direct descent from the Ardennes boars imported by Charles I., and subsequently exterminated during the civil war that marked the disputes of this unfortunate monarch with Parliament; still another survival is seen in the heraldic bearings of certain old families, such as the Gordons, Swintons, Bairds, Trewarthens, etc., all of whom display the boar's head upon coats of arms and in armorial devices.

Though now the Levant, Africa, and India, and in lesser degree the Hellenic peninsula, are the great fields of the sport denominated "pig sticking," in which the boar is ridden down by aid of horses and made to impale himself upon a spear, a mediæval form of hunting still obtains in Brittany and middle Europe. The latter, to be sure, savors largely of what in modern parlance is termed "pot hunting," a phrase employed to designate an unfair advantage taken of the game, in that he has no chance for escape or life, since it has been reduced to rule if not to mathematical certainty, though not wholly devoid of danger, as a plucky animal brought to bay may break away from dogs and charge both beaters and sportsmen. The necessary concomitants of this diversion are a pack of mongrel curs, the more noisy the better, and a blare of trumpets, cymbals, and drums in the hands of a cordon of beaters.

As a matter of fact the quarry appears to care little for the yelps and cries of the pack, so essential to determining his whereabouts; he knows dogs, having doubtless encountered them time and again during nocturnal rambles, never coming off second best. But when he catches the discordant alarm raised by the beaters, terror seizes his porcine soul, he loses his accustomed courage and acumen, and takes to his heels in consternation and dismay. Turning neither to left nor right, he holds his course for the nearest pond, hoping to find a hiding place among the rushes, or to put its waters between himself and pursuers; or, if he pauses, it is only to chastise some impertinent, over-

confident canine, whom he tosses in air by a quick upward thrust of the powerful snout, the victim falling to the earth with bowels protruding from the awful gash made by the long and trenchant tusks. It is only when surrounded that he turns at bay, and then, usually from the vantage of the root spurs of some massive tree, he manages to keep the pack at respectful distance until the hunters gather and terminate the scene with hanger or bullet. His one weak point, as with his barnyard relative, is the ear, and should some knowing and adventurous canine succeed in seizing this, he squeals as lustily as any porker under gate, and without farther pretense at defense yields himself a passive victim to the knife.

It is impossible for those who have never encountered him in his native haunts, and whose ideas are derived from the hog of civilization, to realize the fierce aspect of the creature as hunted or brought to bay—his huge neck and crest bespined with blackish-brown bristles; his lumbering, awkward, yet swift gallop; his champing tusks, rattling like castanets, tossing off bits of adhesive foam that appear like flakes of snow against his brindled hide; the bold charge at an opponent, and strength that will lift horse and rider from the ground, leaving in the flank of the former the print of his keen teeth as an extended gory rut! All in all, he presents so perfect a picture of malignancy and ferocity it is little wonder Mahometans and Parsees accept him as a special creation of the arch fiend and the epitome of incarnate evil, or that Hindoos and early Christians condemned his body as being the constant abode of outcast spirits and wandering demons. "Of all the animals killed by me," says Captain Shakspeare, nicknamed the East Indian Nimrod, "not one ever made good its charge against my spear or in the face of the deadly bullets of my heavy rifle, save the wild boar and panther;" and the exception admitted as regards the former doubtless is due to the fact the shoulders of the creature are protected by a tough layer of cartilaginous tissue, incased in still tougher and exceptionally thick hide, in turn overlaid by a growth of dense, matted, elastic hair, the whole forming what is technically called "the shield," and all but bullet-proof. Little wonder the blades of boar spears require to be of most carefully tempered steel, with edges as fine and keen as surgeon's knife or barber's tool!

The prone double wedge-shaped form of the wild boar, with a length of fifty inches and height at the crest often exceeding an English ell, appears especially well adapted to his modes of life, particularly the forcing of jungles and thickets, and uprooting of virgin soil, etc.; and although his habits are gross, his appetites all impure, his sensations for the most part associated with lust and gluttony, he surpasses in intelligence most creatures that excel him in personal beauty and grace. Further, in strength, in speed, in capacity for endurance, in proportion to size and bulk, he is unapproached by any four-footed member of the zoological kingdom. And while "filthy as a hog" has passed into a hackneyed household adage, it possesses no applicability to the feral form, since his lair is the personification of neatness, and he permits no personal contamination that has not primarily a sanitative purpose. To be sure he rolls in the mud and mire, but solely to rid his hide of ticks and vermin that are concomitant to his habitat, yet even then he carefully bathes and purifies himself in some clear pond or running stream ere is sought the thicket that hides his couch.

In the language of French woodcraft, which is now generally adopted by civilized sportsmen, suckling boarlings, wearing a livery of two shades of brown longitudinally striped upon a ground of white and fawn, are termed *marcassins;* when six months old they are *betes rousses;* at twelve months *betes de compagnie*, as they go in herds or troops with the sows. A boar of the second year is *ragot* and lives alone; of the third year, having attained what may now be held his majority, since he is fit for the chase, is *sanglier*—an abbreviation of *sanglier a son tiers-an.* With the lapse of another twelvemonth he becomes *quarternnier*, after which, with each year he attains successively the titles of *solitaire*, *grand sanglier*, *vieux sanglier*, and *viel ermite*. Other titles depend upon some deformity or peculiarity of life or development; thus a pig with one toe larger than its fellow, or of twisted or crescentric form, is *pigaches*—contraction of *des pieds gauches;* he is *farrowed* on attaining his full number of permanent teeth, and *brimming* in late November and early December, the season of rut, when he is most dangerous and formidable, raging through his haunts disdaining to shirk affray with man or beast.

Should he encounter another of his kind while brimming a battle ensues, apparently of most terrific character, since the forest aisles echo and re-echo to the clashing tusks. At the same time the surroundings are made vocal with squeals and grunts, readily distinguished by the human ear a half mile or more away. As a matter of fact, however, though two boars fight persistently and long, the conflict is one of endurance rather than wounds, the thrusts mutually given being received for the most part upon the matted front or "shield."

From the time he is *ragot*, the boar is always solitary, except as he may incidentally be compelled to associate with others on a common feeding ground, and is wont, usually, to choose his lair in the darkest and most inaccessible recesses of forest, swamp, or jungle, from which he never ventures forth save at night, or as routed by foes or driven by stress of food. With the declining sun, however, he steals away stealthily, ranging hither and thither in search of provender, little coming amiss to his omnivorous appetite. Reptiles, hares, moles, mice, birds, eggs, beetles, and even carrion at times, are eagerly devoured; likewise acorns, chestnuts, beechnuts, and other mast when available; and in season he is inordinately fond of potatoes, grain, and grapes, rooting up fields and trampling down vineyards in order to secure these dainties.

"The boar out of the wood doth waste it" to the poor fellahen and peasant possesses a significance no less calamitous than in the day of the psalmist; for in portions of Egypt, Palestine, Syria, even farther Turkey, Persia, and the Caucasus, it is impossible to cultivate other than inferior forms of barley or grapes, of a class the wild swine will not touch; and travelers in the Orient generally, and especially in Asia Minor, are wont to remark upon the almost continuous evidences afforded of wild boars' occupancy—the groves scored by tusks; rocks plastered with mud where they have scratched themselves; whole fields uprooted to the depth of a foot or more in furrows the width of the creature's head as if recently plowed, the delusion being more perfect in that the herds of sows and boarlings are wont to move in parallel lines while feeding; the approaches to watercourses cut up by their hoofs, and fords made dangerous or impassable by the number of wallows, etc.

In Hindostan and farther India too the boar is no less a plague, since he sedulously devastates the paddy fields and sugar plantations, particularly the latter, and will undergo no end of trouble and fatigue to gratify a "sweet tooth" that is as persistently implanted as in any member of the ursine family. Indeed, his long head harbors a brain of wonderful fertility and infinite cunning, and he appears to fully realize the penalties that attach to an appetite gratified at the expense of the labors of civilization. And while his lair may be in the very midst of plenty, usually he is astute enough to confine his midnight ravages to regions most remote, often miles away, disappearing from the latter with the dawn.

Sportsmen are well aware of this peculiarity, and consequently early sunrise is the favorite hour for a pig-sticking meet, since then the creature usually has gorged himself to repletion and consequently is less capable of endurance and speed. Of course, the more readily winded, the quicker he is ridden down, brought to bay, and impaled upon the spear. Frequently, too, as the result of excessive gluttony, by daylight he is so slothful it is necessary to drive him into the open by means of beaters armed with rattles and tom-toms; but once fairly afoot, despite an overloaded paunch, he puts the best steeds and boldest riders upon their mettle, as he has a trick of selecting a line of country fit to appall the hardest of hard riding fox hunters. Scaling steep ascents, dashing through millahs and over ditches, on he goes; and if a descent too abrupt for scrambling or sliding bars the way, he simply tucks all four feet beneath his body, and flings himself headlong to the bottom, striking upon knees and "shield," only to be up again in a trice, and perhaps miles away before his pursuers can find road for their cattle. Even in the open, with ground most favorable to riding, after getting his "second wind," he not infrequently distances the field and regains his lair in safety.

A friend, resident of Hyderabad, assured me he had repeatedly encountered boars so fierce and game that no horse would or could stand before them, much less permit of sufficiently near approach to flesh a spear by casting. And by their agility and fierce charges they would, perhaps, fairly worst the hunt and drive it from the field. Upon his own estate, too, at least a score of times each season for several consecutive years, he routed the same *viel ermite*, readily recognized by the loss of an ear, and in the selfsame locality, yet could never so much as inflict a wound upon him. And, finally, the ravages of the creature became so great it was found necessary to dispatch by means of a rifle—a procedure that under ordinary circumstances would be deemed unjustifiable and unpardonable, and one calculated to lose caste to its author both among native and European sportsmen. On this occasion, however, the *contretemps* was overlooked as being one wrought of emergency and necessity.

Most sugar estates have one or more disused or abandoned wells, the sides of which have fallen in, leaving a shallow pit or depression, and the margin outlined by a rank growth that has sprung up by reason of moisture; and these are apt to be favorite lurking places for wild swine, both boars and sows, who, by a bit of excavating and taking advantage of the superabundant herbage, are enabled to screen themselves from prying eyes, even though one stands on the very brink. In such situations, especially if the pig is in hiding, owing to being surprised by sunrise too far away from his lair, nothing will rouse but fairly tumbling in atop of him, or the inquisitiveness of a large pack of curs.

As old age advances, the males become more gross, more fat, more unwieldy and every way less formidable, especially as the lower tusks by extension gradually curve backward and outward until they are no longer available for offense. Some compensation, however, is had in the upper canines that hitherto had been kept short by constant attrition upon the lower, as they now take an upward and outward turn with corresponding elongation, until their points appear above the level of the snout. Nevertheless a boar who has for some years been *viel ermite* is much less formidable than a *ragot* or *sanglier*.

The wild sow is seldom encountered alone, but surrounded by a numerous family, as each litter is wont to follow at her side for at least two seasons.

The *marcassins* are kept sedulously concealed in some out-of-the-way thicket until weaned, and their hiding place carefully watched lest some prowling boar or jealous sow should discover their presence, under which circumstance the interloper is sure to develop an unmistakable cannibal appetite. It is no uncommon affair for a whole litter to be thus devoured, and the slaughter once accomplished, it is said the mother does not disdain the remnants of the feast.

Though in the main a faithful parent, the sow cannot be omnipresent. She must seek food, and in some measure care for the *betes* that still claim a share of her attention. Hence her watchfulness is not that of standing guard, but rather manifested by skirmishing in a circle at a distance from the nurslings' covert, and in a way to at the same time secure sustenance and intercept marauders. So, too, she returns to the litter as infrequently as consistent with the duties of maternity, her movements being characterized by secrecy and caution, for she must throw off their guard and slip away from the elder offspring, lest they should betray her secret.

About the fourteenth week, being now able in some measure to forage for themselves, the weanlings are led forward to join the *betes* and learn to do battle with the world. About this time, too, all the sows and youngsters of the same district associate in a single herd, apparently entering into an alliance of mutual protection and defense. And though not provided with as effective weapons as the boars, the mothers are much more dangerous to encounter, since they compensate in energy and numbers for any loss in length of tusks. The fiercest male may be made to "save his bacon" by flight, but a sow with a litter at her tail will constantly assume the offensive and do battle to the very last gasp.

Strange to say, nearly every litter affords at least one weakling, a simple, foolish brute whose early life is made up of a continual round of teasing, tormenting, and submission to the caprices of his brethren. With a disapproving grunt the mother nudges him to one side, taking the very food out of his mouth, perhaps, which is the signal for all others of the family to manifest their rancor and spite. Do what he will or may, he is ever in the wrong. Even the ordinary means of subsistence are obtained only through strategy and artifice, so that by the time he is *ragot* he promises to become a troublesome customer, more fond of prowling and sneaking than open feeding, of running than fighting, but possessed of inordinate malignancy and cunning. But, let one of another family coterie venture to manifest contempt, or to impose upon this bantling, the mother is sure to be down upon him in a hurry, with all her squealing progeny at her heels, when woe to the offender! He may now deem himself fortunate if he escape being torn limb from limb. Such scenes, too, are the cause of frequent and fierce internecine quarrels that are fatal to scores of youngsters—a wise provision of nature, doubtless, to prevent the overstocking of districts; yet, at the first signal of danger, all is forgotten, and ranging themselves with the weaklings in the center, the sows present a bold front and gleaming circle of tusks to the common foe. A quarrel or battle once suspended or decided, the cannibal instinct asserts itself, and the victims of the fray provide a feast for both victors and vanquished.

Wild boars, the world over, are undoubtedly the same specifically. To be sure this has been a matter of question and dispute, and the Ottomans are wont to declare the Bosphorus and Mediterranean mark the bounds of two different forms. Yet the former has no scientific basis of evidence, and the latter rests upon religious superstition rather than any source of zoological information. Mr. Thomas Atkinson, author of two charming works on Siberia and the Amoor country, could detect no differences between the wild swine of Russia and those of trans-Ouralian steppes; and Ehrenberg and Hemprich, both able naturalists, insist upon the identity of the boars of India, Persia, Palestine, Egypt and Barbary with those of the Iberian and Hellenic peninsulas. The Asiatic pig sometimes presents a more prone form and longer snout than the majority of his European brethren. Yet the same peculiarity is observed among the denizens of the forests of Upper Saxony and Zeeland, and undoubtedly is the outcome of special habitat and the necessities of existence.

650 Congress Street East, Detroit, Mich.

THE TREATMENT OF TYPHOID FEVER.

To the Editor of the Scientific American:

You recently published the late Sir William Gull's views as to the best plan of treatment for typhoid fever. Due to the pre-eminence of your journal and to the eminence of the late Sir William, anything emanating from either source must have great weight. Still, to err is human; and if there were any errors in these views of Sir William, relating as they do to a most vital matter, to allow such errors to pass unchallenged and to be perhaps adopted as truth and as a rule of practice by a host of young medical men on both sides of the water must prove no less than calamitous—an international calamity.

To be brief—after 21 years of hospital and private practice, during which time the treatment of this malady was almost a daily duty, I beg leave to oppose with all possible vigor and emphasis the first and seventh of Sir William's fourteen points in its treatment. His first is that typhoid cannot be aborted in its early stage. I differ from this. I know very many cases *can* be aborted in the first few days or week, because I have time and again aborted them by saturating the patient's blood with quinine. It is to-day an axiom of all medical schools that quinine is a *bitter* enemy of all pathogenic microbes. It is *the one* remedy which, taken in sufficient doses, is credited by the profession with warding off "catching" diseases, and the microbes of typhoid are no less its victims than those of grippe or cholera. In the early stage of typhoid, before the characteristic inflammatory lesion is developed in the bowel, the system may be compared to the sheepfold just visited by a flock of birds of prey or pack of hungry wolves; but instantly the enemy (quinine) comes, and lo! there is a rapid retreat and no serious damage is done.

I should be greatly disappointed if in a canvass of the leading practitioners of this country the majority did not sustain me in the views just stated. I know there are some unbelievers. So much for Sir William's first.

As to his seventh, that "wine or liquor should be given to overcome wakefulness, and not opiates, which are injurious or hurtful," I am sure that *no* eminent or successful American practitioner will for one moment indorse such view.

The three prime causes of death from typhoid are inanition (starvation), exhaustion from want of sleep, and hemorrhage. If a patient enter on the full course of typhoid with light body weight (they lose one-fourth to one-sixth of the body weight during the course of the malady) and take little nourishment throughout, crape can safely be purchased for the door in advance. If a patient rave a week or two and you do not put his brain into a strait-jacket with opiates, nineteen chances out of twenty he will die of exhaustion, and crape can be safely purchased in advance. And if he die, why is it less than manslaughter, if not murder, since the A B C of our knowledge of this malady teaches us that wild delirium and continuous loss of sleep cause fatal exhaustion?

If from the beginning an equal diffusion of the blood into all parts of the patient's body (a condition upon which all health and longevity depend) be effected by warm stirpes and poultices to the abdomen, and by bottles of hot water continuously applied to the limbs and extremities, there will be no excessive congestion or inflammation in the bowels, the bowel

lesion will pass through gentle stages, there will be *no* enteric hemorrhage, and so no death from hemorrhage.

Liquor—yes, we give a little of the purest liquor in almost every, if not every, case for its proper uses, to sustain the heart, to cheer the mind, to stimulate the stomach, to diffuse the blood equally through all parts of the body, to open the pores, the greatest of all eliminators of the specific poison; but for sleep we give the remedies best and most proper for that purpose, and here opium, like life itself, is truly *donum Dei*, the best gift of God. T. J. HUTTON, M.D.

St. Paul, Minn., Sept. 5, 1892.

THE LIQUEFACTION OF GASES.

By VAUGHAN CORNISH, M.Sc., F.C.S.

THE common liquids, such as water, rock oil, mercury, and so on, can be readily converted into gases; but many of the common gases, on the other hand, for instance oxygen, nitrogen, and hydrogen, can only be brought into the liquid condition by the use of special methods and powerful agencies. Temperature and pressure are the two factors on which it depends whether a body remains in the state of gas or assumes the liquid condition. Low temperature and high pressure are the conditions favorable to liquefaction.

The history of experiments on liquefaction of gases is mainly a record of devices for producing high pressure and low temperature. Sulphurous acid gas is condensed at the temperature of an ordinary freezing mixture, or at the pressure which can be obtained by a hand-worked piston in a tube or barrel. It had been prepared in the liquid state before the year 1800 A. D. Chlorine was condensed by Northmore in 1805, but his experiments attracted little attention till years later, when Faraday had made a specialty of the liquefaction of gases, and the attention of the scientific world was drawn to the subject. Then, as usually happens, forgotten records were found of earlier work on the same lines. The later, but independent, observation by Faraday (1823) of the liquefaction of chlorine is, however, the commencement of the systematic study of the subject. Faraday has the only kind of priority which is of real importance in scientific discovery, that, namely, of being the first to make the subject fruitful, and the first to make its importance generally understood. Faraday had been experimenting on the solid hydrate of chlorine which separates out in yellowish crystals when ice cold water is saturated with chlorine gas. Sir Humphry Davy, to whom at that time Faraday acted as assistant, suggested that the crystals should be sealed up in a glass tube and heated. Davy gave at the time no reason for his suggestion, and Faraday himself did not know what to anticipate from the experiment. The crystals of the solid hydrate were placed at one end of a Λ-shaped glass tube, which was then closed by sealing up the glass in the blowpipe flame. The crystals being warmed to 60° F. underwent no change, but at 100° F. "the substance fused, the tube became filled with a bright yellow atmosphere, and on examination was found to contain two fluid substances; the one (chlorine water), about three-fourths of the whole, was of a faint yellowish color, having very much the appearance of water; the remaining fourth was a heavy bright yellow fluid, lying at the bottom of the former without any apparent tendency to mix with it." At 70° F. the pale portion congealed (*i. e.*, the hydrate separated out), although even at 32° F. the yellow portion did not solidify.

Heated up to 100° F., the yellow fluid appeared to boil and again produced the bright colored atmosphere. It was found that by heating to 100° F. the yellow liquid (fluid chlorine) could be distilled from the pale colored liquid (chlorine water) so as to get them in different limbs of the bent tube. "If, when the fluids were separated, the tube was cut in the middle, the parts flew asunder as if with an explosion, the whole of the yellow portion disappeared, and there was a powerful atmosphere of chlorine produced; the pale portion, on the contrary, remained, and when examined proved to be a weak solution of chlorine in water with a little muriatic acid."

The paper from which the above extracts are taken was read before the Royal Society by Sir Humphry Davy in 1823. In a note at the end of Faraday's paper, Davy says that "in desiring Mr. Faraday to expose the hydrate of chlorine to heat in a closed glass tube, it occurred to me that one of three things would happen, that it would become fluid as a hydrate, or that a decomposition of water would occur (forming hydrochloric acid), or that the chlorine would separate in a condensed state." Further on he remarks, "I cannot conclude this note without observing that the generation of elastic substances in close vessels, either with or without heat, offers much more powerful means of approximating molecules than those dependent upon the application of cold, whether natural or artificial, for as gases diminish only about $\frac{1}{480}$ in volume for every degree of Fahrenheit's scale, beginning at ordinary temperatures, a very slight condensation only can be produced by the most powerful freezing mixtures, not half as much as would result from the application of a strong flame to one part of a glass tube, the other part being of ordinary temperature, and when attempts are made to condense gases into fluids by sudden mechanical compression, the heat instantly generated presents a formidable obstacle to the success of the experiment, whereas in the compression resulting from their slow generation in close vessels, if the process be conducted with common precautions, there is no source of difficulty or danger, and it may easily be assisted by artificial cold, in cases where gases approach near to that point of compression and temperature at which they become vapors."

This "bent tube" method was successfully employed by Faraday in the liquefaction of a number of other gases.

In 1822, the year preceding Faradays's experiments on chlorine, Caignier de la Tour had examined the effects produced by heating volatile liquids, such as alcohol or ether, in closed tubes. In these experiments the liquid put into the tube was sufficient to fill it half full, and the whole of the tube was heated, so that the conditions were different from those of Faraday's experiments. De la Tour observed that up to a certain temperature the liquid continued slowly to evaporate, the bulk of liquid diminishing, and the quantity of vapor increasing. This was the ordinary process of evaporation, which the eye can trace by observing that the position of the meniscus which separates the liquid and the vapor becomes lower and lower as the temperature increases.

When, however, a certain temperature is reached the meniscus suddenly disappears, and there no longer appears to be any liquid in the tube. On cooling the tube, the inverse change takes place with equal suddenness, a meniscus (the line of separation between liquid and vapor) suddenly appears, showing that on lowering the temperature a large amount of liquid is suddenly formed. De la Tour's experiments point to conclusions quite opposite to those of Davy, quoted above; since the "approximation of particles" brought about by pressure was more than counterbalanced by the repellant action of heat.

In 1845, in a second paper on liquefaction of gases, Faraday writes with a mastery of the subject which neither he nor Davy possessed in 1826. He says (*Phil. Trans.*, 1845, p. 155): "My hopes of success beyond that heretofore obtained depending more upon depression of temperature than on the pressure which I could employ in these tubes, I endeavored to obtain a still greater degree of cold. There are, in fact, some results no pressure may be able to effect. Thus, solidification has not yet been conferred on a fluid (*i. e.*, a gas) by any degree of pressure. Again, that beautiful condition which Caignier de la Tour made known, and which comes on with liquids at a certain heat, may have its point of temperature for some of the bodies to be experimented with, as oxygen, hydrogen, nitrogen, etc., below that belonging to the bath of carbonic acid and ether, and in that case no pressure which any apparatus could bear would be able to bring them into the liquid or the solid state." The "bath of carbonic and ether" here referred to, was a device for obtaining a very low temperature, a kind of improved freezing mixture in fact. Thilorier and afterward Natterer had constructed apparatus in which carbonic acid gas could be liquefied by pressure alone. When liquid carbonic acid is exposed to the air at the ordinary pressure, some of the liquid evaporates very rapidly, thereby chilling the lower layers of liquid to such an extent that they freeze, forming solid carbonic acid. If ether be mixed with this solid carbonic acid, and if the pressure be diminished by means of the air pump, the further cooling due to evaporation of the ether reduces the temperature to —110° C. This extremely low temperature was employed in experiments by which Faraday endeavored unsuccessfully to liquefy hydrogen, oxygen and nitrogen. Andrews employed the same means of producing cold, but used more powerful apparatus for compression. Although by combined cold and pressure the above named gases were reduced to less than $\frac{1}{500}$ of their original volume, no liquefaction took place. Andrews also conducted experiments upon the phenomenon observed by De la Tour, and showed that above the "critical temperature" of 31° C. the greatest pressure which he could bring to bear was not sufficient to liquefy carbonic acid, but that, if the temperature were lowered, the liquefaction took place at once.

In the latter and successful experiments on the liquefaction of the "permanent gases," such as nitrogen, oxygen, and hydrogen, the skill of the experimenter has been chiefly shown in the means devised for obtaining temperatures below the "critical point" of these gases. Pictet, of Geneva, who liquefied oxygen in 1877, relied for the production of a low temperature upon the well known principle of latent heat of evaporation. The novelty in his application of this principle lay in the fact that he employed *two* evaporating substances—namely, sulphur dioxide and carbonic acid. By the use of the doubly acting pumps employed in refrigerating machinery (*vide Knowledge*, March, 1891, "Artificial Cold") liquid sulphur dioxide can be obtained having a temperature of —65° C. In Pictet's apparatus the cold liquid sulphur dioxide is contained in an annular vessel, which forms a jacket round the tube in which carbonic acid is condensed by the action of another doubly acting pump.

The liquid carbonic acid is reduced to a temperature of 65° C. by the cooling action of the "jacket," and, consequently, when the pump is reversed and used as an exhaust pump, the evaporation of the cooled liquid produces an extremely low temperature, and the vapor can again be condensed so as to form a liquid jacket round the oxygen tube, having a temperature of —130° C. This tube of copper was made very strong to withstand pressure. The oxygen gas was passed into the tube direct from a strong iron retort in which it was evolved, and thus the pressure continued to rise as more and more oxygen entered the tube. At a pressure of about five hundred atmospheres, the manometer remained stationary, showing that liquefaction had begun. The whole of the tube was at length filled with liquid oxygen, which was examined by opening a stopcock, when a jet of a lustrous liquid issued with great force from the tube, to be speedily dissipated by evaporation.

Cailletet, who worked independently at the same problem, first succeeded in liquefying oxygen on the very same day as Pictet. He employed simpler appliances, and worked on a different principle. He relied for obtaining his frigorific effect upon the *chaleur de detente*, or latent heat of expansion, of the gas with which he was working. The term "latent heat of expansion" is not a very good one, as gas is not cooled by merely expanding to fill a vacuum. When, however, a gas is allowed to expand in such a way as to do mechanical work, the gas loses in heat the thermal equivalent of the mechanical work performed. In Cailletet's experiments, the gas was contained over mercury in the capillary bore of an immensely strong glass tube. The tube was screwed into an hydraulic press worked by the leverage of a large wheel. The experimental glass tube was surrounded by a freezing mixture of which the temperature for the experiments was not lower than about —30° C. So that in Cailletet's experiments no attempt was made to surround the gas with a very cold atmosphere. When the pressure attained three hundred atmospheres the oxygen still remained in the gaseous condition, being much above the critical temperature, but, on suddenly withdrawing the constraining force from the piston of the press, the gas as suddenly expands, the elasticity or spring of the gas drives back the liquid and the piston, and the sudden mechanical effort of the gas is accompanied by a sudden chill sufficient to bring the temperature below the critical point. The liquefied oxygen was seen in the tube immediately the pressure was released. Cailletet's method had the advantage that the process could be watched through the glass walls of the tube. On the other hand, Pictet's arrangement enabled him to prepare a larger quantity of the material, and to observe its behavior when exposed freely to the atmosphere. As we have said, the liquefied oxygen was dissipated immediately by evaporation, so that no examination of its properties could be made. A fine mist, or cloud, which formed when the oxygen evaporated may have been due to small particles of solid oxygen.

Experiments conducted since those of Cailletet and Pictet, fifteen years ago, have been designed so as to permit of the examination of the physical properties of the liquefied substances. This has been effected by obtaining such low temperatures of the material, and such a low temperature of its immediate surroundings, that the evaporation of the liquid (whether hydrogen, oxygen, or nitrogen) only takes place slowly under ordinary atmospheric pressure. In Cailletet's experiments, a liquid was obtained under low pressure, but the surroundings of the liquid were relatively warm, so that the substance could not long remain liquid. In Pictet's experiments the liquid could only be examined by removing it from the cold atmosphere. In the experiments conducted by Dr. K. Olszewski the gas to be experimented on was contained in the innermost of four glass tubes placed one within the other. In the outermost tube was placed solid carbonic acid and ether. By placing this in connection with an air pump, the temperature of the neighboring tubes was reduced to —100° C. This was the method for obtaining low temperatures employed by Faraday in his later researches. Now comes a novelty. Ethylene gas, brought from a Natterer's cylinder, is led into the (second) inner tube. Here it is liquefied by low temperature, and under a considerable pressure. The two innermost tubes (into which the oxygen or hydrogen are presently to be brought) are now surrounded by a tube containing liquid ethylene at about —100°C. This liquid is protected from the warmth of the air by the outermost jacketing tube of carbonic acid ice. By the action of an air pump the pressure on the liquid ethylene is reduced to 10 mm. of mercury (about $\frac{1}{76}$ the ordinary atmospheric pressure); dry air at the same time is cautiously blown through the ethylene to prevent its evaporation from becoming violent. The gas (say oxygen) is now passed into the two innermost tubes. The intense cold produced by the evaporation of the liquid ethylene, the liquid being to begin with at about —100° C., liquefies the oxygen, which is under a considerable pressure. But one more device remains to be mentioned, the most singular of all in Dr. Olszewski's process. The *two* innermost tubes, as has been said, contain the liquefied oxygen. They are now both put into connection with the air pump, and the pressure is cautiously diminished. The liquid in both tubes begins to evaporate, and is thereby chilled. Presently, the liquid in the outer tube begins to evaporate more quickly than that in the innermost one, owing to the fact that it is in contact with the (relatively) warm ethylene tube. The whole of the liquid in the outer tube consequently evaporates while there still remains a considerable portion of the liquid in the innermost tube. The temperature of the innermost tube has now sunk considerably lower than that of the liquid ethylene. Nitrogen can be frozen in this way. By diminishing the pressure on the solid nitrogen, and thereby causing evaporation, Olszewski obtained a temperature of —225° C., or less than 50° C. from the supposed absolute zero of temperature, that is to say, the point at which *all* the heat has been extracted from a body.

The exceedingly cold liquid contained in the innermost tube is protected from the relatively warm ethylene by the non-conducting layer of rarefied gas in the intermediate tube. Consequently, the substance remains liquid at atmospheric pressure, or even at lower pressure, for a space of time (five to fifteen minutes) sufficient to allow of an examination of some of the important physical properties. Thus the specific gravity is determined by measuring the height at which the liquid stands in the tube, hence deducing the volume of the liquid; then collecting the gas after evaporation, and measuring its volume. The weight of a given volume of *gas* is, of course, well known. This is necessarily equal to the weight of the liquid before evaporation. Hence we know the weight of the liquid in the tube. Its volume having been ascertained in the way described, the specific gravity is readily calculated under atmospheric pressure; it is found that—

	Melts at.	Boils at.	Critical Temp.
Oxygen . .	——	—164°	—118·8° C.
			Sp. gr. of liquid.
			1·124 at —181·4° C.
Nitrogen	—214°	—194·4°	—146° C.
			Sp. gr. of liquid.
			0·885 at —194° C.

Hydrogen at —213° C. liquefied under a pressure of 190 atmospheres; with Pictet's temperature of 140° C. a pressure of 650 atmospheres was required. The temperatures recorded in the above observations were all registered with a hydrogen thermometer. The critical point of hydrogen is —220° C.—*Knowledge.*

THE PREPARATION AND ESTIMATION OF PURE PLATINUM.

By Herren F. MYLIUS and F. FORSTER.

THE authors, having recounted the known methods devised by Deville and Stas for the analysis and purification of the metals of the platinum group, and having substantiated the accuracy of the separations of the metals on which they depend, comment on certain disadvantages that these processes possess. They have devised a method by which the platinum may be volatilized from other metals present in small quantity, and with this object in view they have investigated the volatility of such metals as are likely to be present, as well as that of platinum itself when heated in a current of chlorine mixed with carbon monoxide. The formation of volatile compounds of platinum under these conditions has been lately investigated anew by Pullinger, and by the authors themselves, and its appli-

cability was tried by them in the following manner: Five to ten grammes of platinum, preferably in the form of "sponge," contained in a porcelain boat, was heated in a thin-walled tube drawn out to a long neck at one end and attached to an apparatus for generating chlorine and to a gasholder filled with a mixture of carbon monoxide and carbon dioxide produced by the action of sulphuric acid upon oxalic acid. The further end was closed by a cork, and carried a tube dipping into caustic soda to absorb objectionable fumes. The part of the tube containing the boat was heated to about 238° C.

At first chlorine alone was passed over the metal under treatment, and afterward a mixture of chlorine and carbon monoxide. Excess of the former was found to be inadvisable, as dark-colored sparingly volatile products were formed, which, however, were easily sublimed by subsequent treatment with carbon monoxide. Ten grammes of platinum could be volatilized in this way in six or eight hours. The process was found to be unsuited for the analysis of platinum alloys, as the presence of about one per cent. of iridium caused the distillation to proceed very slowly, and considerable quantities of platinum remained in the residue. With sensibly pure platinum, however, no such difficulty occurs, and even thin sheet can be used. The platinum can be easily recovered from the sublimed compounds with chlorine and carbon monoxide by solution in strong hydrochloric acid and decomposition of this solution by the addition of water. The determination of the platinum by this method is not to be recommended, but it may be indirectly estimated by the loss in weight of the contents of the boat.

The behavior of the metals likely to be present in platinum of commercial purity was then ascertained. Iridium gave a sublimate strongly resembling that yielded by platinum, and separation of a trace of iridium from a large quantity of platinum could not be effected. Palladium alone gave no sublimate, but volatilized in the presence of an excess of platinum, only a trace being left in the non-volatile residue. Rhodium was not appreciably volatile; 1 mgrm. could be recognized in 10 grammes of platinum. Ruthenium, osmium, and gold were all volatile. Silver, copper, lead, and zinc were non-volatile, while iron easily sublimed. The method was therefore shown to be available for the metals rhodium, silver, copper, lead, and zinc.

The process can be used to supplement the Deville-Stas method in the following way: The aqua regia solution of platinum containing rhodium and lead obtained in the course of the standard method is freed as far as possible from excess of acid, neutralized with ammonia, excess of formic acid added together with some ammonium acetate, made up of 500 c. c., heated on the water bath to 70°-80° C. until the carbon dioxide which is freely evolved at the beginning slackens somewhat, and then boiled in conjunction with a vertical condenser for 24-30 hours. The precipitated metal is washed with dilute hydrochloric acid and dried over sulphuric acid and caustic potash. The dried metal is heated cautiously in hydrogen, weighed, and treated by the carbon monoxide and chlorine process already in outline described. The non-volatile residue is extracted with nitric acid to remove the lead, while the rhodium is separated from the small quantity of platinum remaining in the boat, by fusion with bisulphate of potash.

Small amounts of impurities in platinum are therefore best determined by the following method: Three distinct portions are taken; the first is tested for palladium, iridium, and ruthenium by the ordinary lead method of Deville and Stas; a second portion is dissolved in aqua regia and the filtrate examined for iron after the reduction of the platinum by means of formic acid; the third is volatilized by the new carbon monoxide and chlorine method, and rhodium, silver, copper, and lead looked for in the residue. The following quantities can be detected if 10 grammes of platinum be used for each operation: Iridium, 0·003; ruthenium, 0·005; rhodium, 0·004; palladium, 0·01; iron, 0·001; copper, 0·002; silver, 0·002; lead, 0·002 per cent. respectively.

Preparation of Pure Platinum.—Commercial platinum is not even approximately pure. Appended are two analyses, the first of a platinum crucible, the second of a sample of "purified" platinum:

	Platinum crucible.	"Purified" platinum.
	Per cent.	Per cent.
Platinum	96·90	99·28
Iridium	2·56	0·22
Rhodium	0·20	0·13
Palladium	trace	....
Ruthenium	0·02	0·04
Iron	0·20	0·06
Copper	....	0·07
	*99·88	99·90

*99·58 in original.

The need for pure platinum for the preparation of standard weights and measures made from a platinum-iridium alloy of known composition was the first cause that led to a serious attempt being made to purify platinum beyond the limits here indicated, and success in this direction has been achieved by the well-known firm of Johnson, Mathey & Co., who use the lead process of Deville and Stas. The authors have detected in the purest samples from this firm 0·01 per cent. of rhodium and 0·01 per cent. of silver, both impurities being among the list of those for the detection of which the carbon monoxide and chlorine method is especially suitable.

Lately Herr W. O. Heräus has engaged in the production of pure platinum, which is stated to be preferable to the English material, as no lead is used in the process of purification. A sample examined by the authors contained only a trace of iridium, not quantitatively determinable, and no detectable amount of palladium or rhodium. The amount of iron present did not exceed 0·001 per cent. Finkener's method for purifying platinum was adopted. It consists essentially in the conversion of the platinum into the double sodium chloride salt and the recrystallization of this salt from a solution made alkaline with soda. The solution of platinic chloride, freed from oxides of nitrogen, was evaporated with the calculated amount of sodium chloride (free from iron) to dryness, and well stirred while cooling. The mother liquor was removed from the crystals, and the latter were washed with a strong solution of sodium chloride and dissolved in a 1 per cent. soda solution. A very small quantity of a dark precipitate containing iridium remained.

The salt separated by the cooling of the filtered solution was repeatedly recrystallized from slightly alkaline solution without the formation of any similar precipitate. The purified salt thus obtained was dehydrated at 120° C., and reduced in hydrogen at a low temperature, the resulting platinum sponge washed repeatedly with water, dried, and ignited, the ignited metal being also washed with dilute hydrochloric acid, dilute hydrofluoric acid, and again with water.

With regard to the purity of the platinum thus prepared, it appeared probable that the maximum limit for the total quantity of foreign matter was 0·01 per cent., that is to say, there was present 99·99 per cent. of platinum. The conclusion arrived at by this investigation is that platinum is a metal which can be brought to a high state of purity with ease and certainty.—*Ber.*, 25, 1892, 665—686, through *Jour. Soc. Chem. Ind.*

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